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ABSTRACT

A series of studies carried out by the Advisory Committee on Academic Planning (ACAP) published by the Council of Ontario Universities (COU) dealt with a planning study of doctoral work in engineering that was conducted in several parts corresponding to the various disciplines within engineering. This document, which is one part of that study, deals with doctoral work in civil engineering. It also contains some recommendations: (1) covering most of the fields of engineering; and (2) dealing specifically with mechanical, industrial, and civil engineering. Appendices include: (1) a report of the ACAP Subcommittee on Civil Engineering; and (2) a report of civil engineering consultants. (Author/KE)

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Council of Ontario Universities

Perspectives and Plans for Graduate Studies

11
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1974/5

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Ontario Council on Graduate Studies

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PERSPECTIVES AND PLANS FOR GRADUATE STUDIES

11. ENGINEERING 1974-75

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Advisory Committee on Academic Planning
Ontario Council on Graduate Studies

75-11

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TABLE OF CONTENTS

Pages

FOREWORD i

REPORT AND RECOMMENDATIONS OF THE COUNCIL OF ONTARIO UNIVERSITIES - Part I 1 to 9
Part II 10 to 11
Part III 12 to 14

REPORT OF ADVISORY COMMITTEE ON ACADEMIC PLANNING April, 1975 1 to 8

APPENDICES

Appendix 1: Report of the ACAP Subcommittee on Civil Engineering 1-1 to 1-33

Appendix 2: University and Discipline Group Comments 2-1 to 2-58

Appendix 3: Procedure for Completing the Civil Engineering Planning Assessment 3-1

Appendix 4: Comments from the Ontario Council on Graduate Studies (OCGS) 4-1 to 4-2

Appendix 5: Comments from the Committee of Ontario Deans of Engineering (CODE) including the Legget Report 5-1 to 5-17

REPORT OF ADVISORY COMMITTEE ON ACADEMIC PLANNING June, 1974 1 to 46

APPENDICES

Appendix A: Report of Civil Engineering Consultants A-1 to A-53

Appendix B: Discipline Group Response B-1 to B-5

Appendix C: University Comments C-1 to C-37

Appendix D: Procedure of Planning Study and Terms of Reference D-1 to D-7

Appendix E: Discipline Group Membership E-1

Appendix F: Roles of ACAP and of Discipline Groups F-1 to F-4

Appendix G: Curricula Vitarum of the Consultants G-1 to G-4

Appendix H: Response of the Committee of Ontario Deans of Engineering (CODE) H-1 to H-14

This report deals with a planning study of doctoral work in engineering which was conducted in several parts corresponding to the various disciplines within engineering. The report is in six volumes. Volume A deals with chemical engineering, B with electrical engineering, C with metallurgical and materials engineering, D with mechanical engineering, E with industrial engineering and F with civil engineering. Each volume contains the COU and ACAP reports for engineering as a whole together with the consultants' report and other material appropriate to the discipline covered.

The COU report is in three parts: Part I dealing with recommendations approved in June, 1974 covering most of the fields, Part II approved in September, 1974 dealing with mechanical and industrial engineering, and Part III approved in October, 1975 dealing with civil engineering. This final volume, printed in the fall of 1975, contains all three parts.

FOREWORD

As a consequence of a study of engineering education in Ontario (described in more detail in the subsequent ACAP report) the Council of Ontario Universities called for a planning assessment of PhD programmes in engineering to be carried out by ACAP in cooperation with CODE.

The Advisory Committee on Academic Planning (ACAP), as presently constituted, was established by the Ontario Council on Graduate Studies at the request of the Council of Ontario Universities in January, 1971. The Advisory Committee's terms of reference were directed broadly toward the effective planning and rationalization of long-term graduate development in Ontario's universities both at the level of individual disciplines and at a more general level. The Advisory Committee's activities are based on the premise that graduate work is the one area of university activity in which specialization among universities, cooperative arrangements and comprehensive planning are most necessary.

The disciplinary planning process involves a discipline group composed of one representative from each university with an interest in graduate work in the planning area. In the case of engineering, CODE was also involved in a way described in the ACAP report. The discipline group assists in defining the precise academic boundaries of each study, and prepares a commentary on the consultants' report.

The final decision on consultants for the planning study is made by ACAP. The consultants are requested to make recommendations on programmes to be offered in Ontario, desirable and/or likely enrolments, the division of responsibility for programmes among universities, and the desirable extent of collaboration with related disciplines.

While the consultants' report is the single largest element in the final report on the planning study, ACAP considers the statement of each university's forward plans to be most significant. These forward plans are usually outlined prior to the planning study, and are used as a basis for comments from the universities concerned on the consultants' report.

On receipt of the consultants' report, and comments on it from the discipline group and the universities, ACAP begins work on its own recommendations for submission directly to the Council of Ontario Universities. COU considers the input from all sources, and prepares the position of the Ontario university community.

The following report is one of a series of disciplinary planning studies carried out by the Advisory Committee on Academic Planning and to be published by the Council of Ontario Universities. The emphasis of the report is on forward planning, and it is hoped that the implementation of COU's recommendations will help to ensure the more ordered growth and development of graduate studies in Ontario's universities.

Council of Ontario Universities
Conseil des Universités de l'Ontario

Report and Recommendations concerning Doctoral Studies in Engineering - Part I

On the instruction of the Council of Ontario Universities, the Advisory Committee on Academic Planning, in cooperation with the Committee of Ontario Deans of Engineering, has conducted a planning assessment for doctoral work in engineering. This arose from the need to re-examine the recommendations concerning PhD work which appeared in Ring of Iron. The background to the study, the procedures followed and the planning techniques used are described in the ACAP report and are not repeated here. The resultant report from ACAP is attached together with the consultants' reports, the comments by the discipline groups, the comments of the individual universities, and the comments of CODE. It is important for the reader to read the attachments in order to understand the recommendations in this Report from COU. COU will issue subsequent parts to this report dealing with mechanical, industrial and civil engineering.

The Council received the ACAP report and supporting documentation on April 11, 1974. The content of the ACAP document was debated on April 11, on May 3, and on June 7, 1974. As a result of these discussions this Report and Recommendations was prepared and approved by the Council on June 7, 1974. The report is addressed to the Ontario Council on University Affairs and the Universities of Ontario.

The following principles have been adopted and will apply to this and all other COU Reports arising out of assessments.

1. Discipline assessments by ACAP should form the basis for planning by the universities of their development of graduate studies, particularly PhD programmes. On the basis of these assessments, COU should make its own recommendations on currently embargoed programmes. Each university must retain the freedom and responsibility to plan and implement its own academic development. However, the universities in embarking on a cooperative planning process have signalled their intentions of cooperating with the COU recommendations.

2. Universities generally plan their emphases in graduate study on the bases of related departments, not of single departments. Initially the sequential nature of the discipline planning assessments makes this difficult. However, by the summer of 1974 there will have been assessments of most of the social sciences, all of the physical sciences, engineering doctoral work, and a number of professional areas. On the information and recommendations then available, each university should be able to make decisions concerning its support of graduate programmes in these areas. Amendments to university responses to the individual discipline planning assessments may then be made in the wider context of a group of related disciplines and amendments to COU's original Reports on an individual discipline may be required.

3. The first concern in planning is to review the quality of graduate opportunities and of students in Ontario universities and to make judgments about how to proceed or not proceed based on quality considerations. The procedures have made use of highly qualified independent consultants who have no direct interest in the universities in Ontario. Accordingly, COU feels bound to accept their judgments about quality where they are stated clearly unless unconvinced that their conclusions about quality are consistent with their evidence. COU's recommendations in the case of programmes which are of unsatisfactory or questionable quality will call for discontinuation or the carrying out of an appraisal, if the continuation of the programme is not crucial to the province's offerings. In some cases, however, there may be a particular need for the programme and the appropriate recommendation will be to strengthen it, with an appraisal following that action. It is also possible that if there were found to be too large a number of broadly-based programmes there could be a recommendation to discontinue the weakest; in this case, an appraisal for a more limited programme might be relevant.

4. A second consideration is the scope of opportunities for graduate work in the discipline. Do the Ontario programmes together offer a satisfactory coverage of the main divisions of the discipline?

5. Numbers of students to be planned for will depend on the likely number of applicants of high quality and in some cases may relate to an estimate of society's needs. Such estimates may be reasonably reliable in some cases and not in others. If the plans of the universities appear to be consistent with the likely number of well qualified applicants and there is either no satisfactory basis for estimating needs or there is no inconsistency between a reasonable estimate of need and the universities' plans, then COU will take note of the facts without making recommendations on the subject of numbers.

   If the numbers being planned for by the universities are grossly out of line with the anticipated total of well qualified students, or a reliable estimate of needs, COU will make appropriate corrective recommendations. Depending on the circumstances, these may call for a change in the total numbers to be planned for and indications of which institutions should increase, decrease, or discontinue. The recommendations in serious cases may need to specify departmental figures for each university for a time. If the numbers being planned for are insufficient, the recommendations may call for expansion, or new programmes, and may have implications for both operating and capital costs.

   Unless there are exceptional circumstances, the recommendations concerning enrolment will not call for a university to refuse admission to any well qualified student who wishes to work in a field in which that university offers a programme and in which it has the capacity to accommodate the student.

6. The quality of graduate programmes is partly dependent on size, and for each programme, depending on how it is designed and its scope, there is a minimum size of enrolment below which quality may suffer. That number cannot be expressed for the discipline as a whole but only for individual programmes depending on their purpose, their resources and their design.

7. Universities will be expected to notify COU if they intend to depart from the COU Report in any way which they believe might have a significant bearing on the provincial plan.

8. Appraisals arising as the result of assessments are to be based on the standards but not necessarily the scope of the acceptable programmes in the province.

General observations concerning engineering doctoral work

1. Ontario is unlikely to over-produce engineering PhDs in the next five years. However, the student body contains too large a proportion of non Canadians. Qualified Canadians should be encouraged to seek the engineering PhD.

2. Doctoral students should be selected on the basis of high academic standing and research potential.

3. "Inbreeding" is a problem, with many students obtaining three degrees from one university.

4. Faculty members, whether or not engaged with doctoral students, should have the facilities and opportunities to engage in research and in work with industry.

5. The scope for interuniversity and university-industry cooperation is considerable and should be exploited.

6. The quality and state of development of the Ontario doctoral programmes are variable. Some are very good and have gained international recognition.

7. Some universities are organizing (or reorganizing) doctoral study on a division of specialization other than that provided by the "traditional" engineering departments. In two of the smaller faculties this is a central factor in the planning, but increasing cross-departmental activity is also in evidence elsewhere.

Actions by COU

1. COU has abandoned a planning number of 450 doctoral students and advises the universities to plan on the assumption that the doctoral enrolment will remain roughly constant for the next five years. Although there is a need for engineers with doctorates in Ontario, graduate student enrolment will level off due to a lack of top quality students. Canadians must be attracted in increasing numbers in order to maintain enrolment at the present level.

2. COU requests that CODE report annually to COU on enrolment and employment opportunities.

3. COU requests that ACAP arrange for each engineering discipline group:
   (1) to monitor annually the admissions experience of each programme (post *facto*) and report on the quality of the admitted students (to ACAP for transmission to COU);

   (2) to report annually to ACAP on the universities previously attended by the newly admitted graduate students of each department.

4. COU requests CODE, after consultation with the discipline groups, to develop proposals for collective methods of making information on graduate work in all Ontario universities readily available to the engineering students, and to inform ACAP of the action taken.

5. COU requests OCGS to examine existing university guidelines on part-time doctoral work and its supervision.

6. COU request that ACAP arrange for an annual report to OCGS from each university on the time taken for each graduating student to complete his doctoral studies.

7. COU requests ACAP to examine the available documentation on civil engineering, to reach its own judgements on the basis for a report, after soliciting assistance from the discipline group and the universities, and to prepare its report to COU containing recommendations for the future of civil engineering doctoral work. This should be submitted by December 31, 1974.

8. COU requests that ACAP arrange for the metallurgical and materials engineering discipline group to present a report to ACAP on university actions taken to correct identified weakness in certain fields of study.

Recommendations

It is recommended that:

1. Universities, CODE and discipline groups take steps to inform potential candidates of the value of a PhD in many phases of government and industry, not only in research and development. The universities, individually and collectively, through agencies such as CODE, should discuss with the industrial and governmental employers steps to be taken jointly in order to overcome the shortage of Canadian students.

2. The universities attempt to maintain the situation where Canadians and landed immigrants constitute at least 70% of the doctoral enrolment in any programme, at any one time, even though the number of landed immigrants may decrease.

3. The universities, the provincial government, and granting agencies examine the extent to which the limit to student income deters Canadians from entering graduate work. Means of supplementing the income of professionally experienced students should be examined.

4. All doctoral thesis examining committees have an examiner external to the university.

5. At present, there not be any specific engineering doctoral part-time programmes but rather that part-time or non-resident doctoral work be done by individual arrangement. Experimentation in methods of carrying on part-time work is to be encouraged and might lead in future to the creation of specific part-time programmes. It is also recommended that the research topic of any student accepted on a part-time basis be in a field in which the professors in the department have expertise.

University Recommendations

Engineering was split into five separate assessments, one for each of the five traditional fields of engineering. Two universities, Western Ontario and Windsor, do not administer their doctoral engineering work along these lines but rather on an interdisciplinary basis that cuts horizontally across engineering. For this reason, these two universities are being dealt with separately and not as part of the more standard approach evident in the five assessment reports. Similarly, Guelph also is included in this section.

It is recommended that:

6. The University of Western Ontario continue its examination of its PhD programme in engineering science, and put forward the resulting programme for appraisal, in particular delineating carefully the areas of research in which it feels it appropriate to accept students. If a favourable appraisal is not obtained by the end of October, 1976, admission of new students should then be suspended.

7. The University of Windsor continue the reorganization of its doctoral work in engineering and submit all programmes for appraisal when the new system has been in operation sufficiently long to permit a valid appraisal. Enrolment of new students should cease after October, 1977, if a favourable appraisal has not been obtained.

8. The involvement of the School of Engineering in the hydrology doctoral programme at the University of Guelph continue and that the university begin doctoral work in agricultural engineering at a time in accordance with the University's plans, subject to normal appraisal procedures.

Chemical Engineering

This section deals with doctoral work in chemical engineering at McMaster, Ottawa, Queen's, Toronto and Waterloo.

It is recommended that:

9. The departments consider grouping their research activities in well defined areas so as to establish or reinforce teams, thus providing a more stimulating environment for students.

10. McMaster University continue its doctoral work in chemical engineering according to its plans.

11. The University of Ottawa continue its doctoral programme in chemical engineering according to its plans.

12. Queen's University re-evaluate its doctoral programme in chemical engineering in the light of comments made by the consultants concerning research activity of the faculty, the grouping of research areas, the awareness of new trends in the discipline, and the mobility of its bachelor's graduates, and submit the programme for appraisal at the time that the university considers appropriate. If a favourable appraisal has not been received by October, 1976, enrolment of new students then be suspended.

13. The University of Toronto continue its doctoral programme in chemical engineering according to its plans, paying particular attention to the desirable mobility of its bachelor's graduates for graduate work elsewhere and to the desirability of grouping of research areas. The University of Toronto is requested to report to COU through ACAP by June, 1975, on action taken in regard to this Recommendation.

14. The University of Waterloo continue its doctoral programme in chemical engineering according to its plans.

Civil Engineering

The consultants' report is unfortunately inadequate for planning purposes.

It is recommended that:

15. The embargo on the funding of any new programmes in civil engineering continue until COU has accepted a report from ACAP dealing adequately with the future role of each department in respect to the different fields of doctoral research, paying particular attention to the relative strengths and weaknesses of each department and the change in emphasis on fields recommended by the consultants. The report should be submitted by ACAP by December 31, 1974.

Electrical Engineering

This section deals with doctoral work in electrical engineering at Carleton, McMaster, Ottawa, Queen's, Toronto and Waterloo.

It is recommended that:

16. The discipline group annually identify those areas of electrical engineering which they consider relevant to the present and future needs of Canada and

make their findings available to the granting agencies and various associations of industry in order to stimulate a continuing dialogue with industry.

17. Carleton University continue its doctoral work in electrical engineering according to its plans.

18. McMaster University continue its doctoral work in electrical engineering according to its plans.

19. The University of Ottawa plan the reorganization of its doctoral programme in electrical engineering and put forward the programme for appraisal. If a favourable appraisal has not been obtained by the end of the fall term 1976, admission of new students should cease. In the meantime, enrolment of new students should be restricted to the digital communications systems and large-scale systems fields.

20. Queen's University continue its programme in electrical engineering concentrating in the communications and systems fields, with occasionally a student in cognate areas of electronics and energy processing. Any proposed substantial developments in these latter two fields should be submitted for appraisal. It is also recommended that the department maintain enrolment at its present level.

21. The University of Toronto continue its doctoral work in electrical engineering according to its plans.

22. The University of Waterloo continue its doctoral work in electrical engineering according to its plans.

Metallurgical and Materials Engineering

This section deals with doctoral work in metallurgical and materials engineering at McMaster, Queen's, Toronto and Waterloo.

It is recommended that:

23. The universities take steps to increase the activity in the ceramics, glasses, and polymer fields of study in the province.

24. McMaster University continue its doctoral programmes in materials science and extractive metallurgy, and make a report to COU through ACAP in the fall of 1975 on the following suggestions for improvement:

    a) recruitment of students with physics and chemistry backgrounds
    b) strengthening of the extractive metallurgy faculty
    c) collaboration with the University of Toronto

25. Queen's University continue its doctoral work in physical metallurgy and discontinue the doctoral programme in extractive metallurgy and mineral engineering as it now exists and replace it by an enlarged programme involving professors from other departments. This new programme should be appraised and this should be completed by December 31, 1976. If Queen's does not wish

to enlarge its programme in extractive metallurgy and mineral engineering, the present programme should be put forward immediately for appraisal, ceasing to enrol new students by June 30, 1975, if a favourable appraisal is not obtained.

26. The University of Toronto continue its doctoral programmes in its Department of Metallurgy and Materials Science. It is suggested that Toronto consider broadening the programmes and it is requested that the university report to COU through ACAP by September, 1975, on any progress made in this direction.

27. The University of Waterloo continue its doctoral work in extractive and process metallurgy and in metallurgical engineering and materials science according to its plans.

Mining Engineering

It is recommended that:

28. Queen's University continue its doctoral work in accordance with its plans.

General

It is recommended that:

29. In view of the acceptance of these recommendations by the Council of Ontario Universities and the completion of Part I of this planning assessment, the Ontario Council on University Affairs request the Minister to remove the embargo on doctoral work in Engineering (except for Mechanical, Industrial and Civil Engineering at Carleton, McMaster, Ottawa, Queen's, Toronto and Waterloo), in accordance with the original announcement of the Minister that new graduate programmes would be embargoed until, for each discipline, a planning study has been conducted.

Notes concerning the recommendations

Re: Recommendations 1, 2, and 3

The background to these important recommendations appears on pages 13 and 14 of the ACAP Report.

Re: Recommendation 7

Presumably the programmes submitted for appraisal will be the three divisional programmes which are replacing the departmental programmes.

Re: Recommendation 16

Other engineering discipline groups may also find this a valuable suggestion.

Re: Recommendation 19

This differs from the recommendation in the ACAP Report because the University subsequently decided to carry out a reassessment of the future direction of the department.

Re: Recommendation 25

Queen's has reported to COU its intention to enlarge its programme in extractive metallurgy.

June 7, 1974.

Council of Ontario Universities
Conseil des Universités de l'Ontario

Report and Recommendations concerning Doctoral Studies in Engineering - Part II

As Part I of this report indicated it would, this part deals with mechanical engineering and industrial engineering and systems design. Civil engineering will be dealt with in Part III.

The ACAP reports on mechanical and industrial engineering were debated by COU on June 7, 1974. As a result of these discussions, Part II of the Report and Recommendations was prepared and approved by Council on September 6, 1974.

The principles, general observations, actions by COU and recommendations 1 - 5 given in Part I apply generally and therefore have application to mechanical and industrial engineering. Similarly recommendations 6,7 and 8 deal with doctoral work in engineering at Western Ontario, Windsor and Guelph, and, although the consultants' reports in mechanical and industrial engineering will be of value to these universities, no recommendations for them follow.

Mechanical Engineering

This section deals with doctoral work in mechanical engineering at Carleton, McMaster, Ottawa, Queen's, Toronto and Waterloo.

It is recommended that:

29. Carleton, McMaster and Queen's Universities continue their doctoral programmes in mechanical engineering and during the coming year give careful consideration to the feasibility of a stronger development of foci of interest in the special areas of strengths suggested by the consultants. The Universities are requested to report to COU and OCGS, through ACAP, during the fall of 1975, on the results of these considerations.

30. If the University of Ottawa wishes to reactivate a doctoral programme in mechanical engineering, it give careful consideration to the need for the department to have suitable industrial and research experience before applying for appraisal.

31. The University of Toronto continue its doctoral programmes in mechanical engineering in its Department of Mechanical Engineering and the Department of Aerospace Studies and Engineering. The University should consider the consultants' recommendation of a greater concentration of research activities of the Department of Mechanical Engineering on major problems of national concern. It is recommended that the University inform COU and OCGS through ACAP, during the fall of 1975, of any decisions taken.

32. The University of Waterloo continue its doctoral programme in mechanical engineering. The University should consider the consultants' recommendation of a greater concentration of research activities on major problems of national concern. It is recommended that the University inform COU and OCGS through ACAP, during the fall of 1975, of any decisions taken.

Industrial Engineering and Systems Design

This section deals with industrial engineering at Toronto and systems design at Waterloo.

It is recommended that:

33. The University of Toronto continue its doctoral work in human factors engineering, management information systems and operations research.

34. The University of Waterloo continue its doctoral programme in systems design.

Notes

Re: Recommendation 33

The University of Toronto is advised to expect about the same enrolment in doctoral work in industrial engineering as it now has, at least until such time as some new field of specialization may be approved.

Re: Recommendation 34

The University of Waterloo is advised to give careful attention to the consultants' recommendations for strengthening its systems design doctoral programme before allowing the enrolment to grow.

August 27, 1974.

Council of Ontario Universities
Conseil des Universités de l'Ontario

Report and Recommendations concerning Doctoral Studies in Engineering - Part III

As Parts I and II of this report indicate, Part III deals with civil engineering. The ACAP report together with the OCGS comments were discussed at the September 12, 1975 meeting of COU. As a result of these discussions, Part III of the Report and Recommendations was prepared and approved by Council.

The principles, general observations, actions by COU and recommendations 1-5 given in Part I apply generally and therefore have application to civil engineering. Similarly, recommendations 6, 7 and 8 deal with doctoral work in engineering at Western Ontario, Windsor and Guelph and, although the report by the ACAP Subcommittee on Civil Engineering included these universities, no recommendations for them follow.

Subsequent to the circulation of the report of the ACAP Subcommittee, criticisms of the process were made by CODE and the discipline group. COU shares the views expressed in the OCGS report about the procedures followed for this planning assessment. However COU also shares the view of OCGS that the ACAP recommendations are "moderate in tone and workable in practice". COU in supporting the recommendations (below) does not attach value to and does not accept the quality rating used by the ACAP Subcommittee, for the reasons expressed in the OCGS commentary.

Civil Engineering

This section deals with doctoral work in civil engineering at Carleton, Ottawa, McMaster, Queen's, Toronto, and Waterloo.

It is recommended that:

35. The Discipline Group arrange discussions amongst the concerned universities regarding the coverage of subfields of civil engineering doctoral study in transportation in Ontario.

36. Carleton University

    a) continue its doctoral programme in the field of transportation studies, making every effort to strengthen this group;

    b) continue its collaborative doctoral programme with the University of Ottawa in the field of geotechnical engineering and, together with the University of Ottawa, formulate academic regulations that will tend to emphasize the responsibility of the whole group for the progress of each student;

c) initiate conversations with the University of Ottawa to develop arrangements for collaboration in the field of structures on the same basis as that described for geotechnical engineering.

It is recommended that the two universities report to COU by December, 1975, on the results to that time of the actions recommended in b) and c). It is recommended that if the report on b) is not satisfactory to COU, each university should then cease enrolling doctoral students in geotechnical engineering until such time as it has obtained a favourable appraisal for work in that field. It is recommended that if the report on c) is not satisfactory to COU, Carleton should cease to offer the PhD in the field of structures.

37. The University of Ottawa

a) continue its doctoral programme in the field of water resources;

b) continue its collaborative doctoral programme with Carleton University in the field of geotechnical engineering and together with Carleton University, formulate academic regulations that will tend to emphasize the responsibility of the whole group for the progress of each student;

c) engage in conversations with Carleton University to develop arrangements for collaboration in the field of structures on the same basis as that described for geotechnical engineering.

It is recommended that the two universities report to COU by December, 1975, on the results to that time of the actions recommended in b) and c). It is recommended that if the report on b) is not satisfactory to COU, each university should then cease enrolling doctoral students in geotechnical engineering until such time as it has obtained a favourable appraisal for work in that field.

38. McMaster University continue its doctoral work in civil engineering in the field of structures according to its plans and, as resources become available develop work in another field, other than structures or geotechnical engineering.

39. Queen's University continue its doctoral programme in civil engineering in the fields of hydraulics, geotechnical engineering, and structures according to its plans, strengthening the geotechnical group if possible and submitting the structures work for appraisal in the fall of 1977, ceasing to enrol new students in this field if the appraisal is not favourably completed by June, 1978.

40. The University of Toronto continue its doctoral programme in civil engineering in the fields of environmental engineering, geotechnical engineering, structures, and transportation according to its plan.

41. The University of Waterloo continue its doctoral programme in civil engineering, in the fields of structures, water resources, transportation and geotechnical engineering according to its plans, but that it submit the work in geotechnical engineering for appraisal in the fall of 1977, ceasing to enrol new students in that field if the appraisal is not favourably completed by June, 1978.

42. In view of the acceptance of these recommendations by the Council of Ontario Universities, the Ontario Council on University Affairs request the Minister to remove the embargo on doctoral work in engineering in accordance with the original announcement in 1971 concerning embargo of graduate programmes, since this, together with the two earlier parts of the Report, completes the planning assessment of engineering.

October 24, 1975.

Draft revised October 3, 1975

ADVISORY COMMITTEE ON ACADEMIC PLANNING

ONTARIO COUNCIL ON GRADUATE STUDIES

REPORT TO THE COUNCIL OF ONTARIO UNIVERSITIES

on

Civil Engineering Doctoral Planning Assessment

April, 1975

INTRODUCTION

The doctoral planning assessment in civil engineering has been completed in an unusual manner. Since the report of the original team of consultants failed to provide sufficient discussion of quality to give confidence that it provided a satisfactory basis for planning purposes, COU instructed ACAP "to examine the available documentation and reach its own judgments on the basis for a report, after soliciting assistance from the Discipline Group and the universities" and "deal(ing) adequately with the future role of each department in respect to the different fields of doctoral research, paying particular attention to the relative strengths and weaknesses of each department and the change in emphasis on fields recommended by the consultants". This task was carried out by a subcommittee of ACAP in accordance with a procedure approved by COU. The subcommittee contained an engineer from outside the Ontario university system. A more detailed account of the history of this study is found in the subcommittee's report, pages 1-1 and 1-2.

The attachments to this ACAP report are a very important part of the whole. They include not only the subcommittee's report and the comments on it but also the original consultants' report and additional appendices written in 1973. They all provide valuable background information for this ACAP report and should be read at the same time. As has been our custom with other disciplines, we prefix our recommendation to COU with the symbol 'C' to avoid confusion with numbering in the COU report. The numbers are sequential with the earlier ACAP report on engineering.

Three general complaints have been frequently referred to in the university and Discipline Group comments. The first concerns the importance of professional activities and the feeling that the subcommittee did not give these activities sufficient weight when they considered various programmes. ACAP agrees that professional experience is important and is satisfied that the subcommittee also understood its importance as one of the factors contributing to the success of a supervisor of doctoral students.

The second problem concerns the fact that the subcommittee did not visit the departments to speak with faculty and students and to see the laboratories and other facilities. The subcommittee members felt that the visits would not have helped them appreciably more than the statements and data already provided to them by the departments and the full and helpful interviews with department chairmen. Most significantly, they feel that visits would not have affected any of the recommendations regarding "the future role of each department".

The third and final point concerns the fact that there was not a civil engineer on the subcommittee. It was felt that an engineer with wide experience, perhaps a dean, would be more helpful to the ACAP members, and CODE "accepted that there is more to be gained at this stage of affairs through having an engineer not from the Civil Engineering discipline and also one with the widest possible general experience". In view of the past history and current status of this planning assessment, this decision appears to have been wise.

A major area of contention centres around the quality ratings and their meanings. These are explained on page 1-12 of the subcommittee's report, and in their addendum. It would not seem to be valid procedure for ACAP to attempt to substitute other quality judgments without itself repeating the work of the subcommittee; it would be appropriate to refer the report back to the subcommittee for reconsideration if this appeared warranted. After study of the university comments, ACAP sees no reason to refer the report back.

On the other hand, ACAP as a whole gave particular attention to university comments which could affect a recommendation.

GENERAL RECOMMENDATIONS

There are two recommendations of a general nature in the subcommittee's report, one concerns the possible initiation of a Doctor of Engineering degree programme and the other future development of transportation studies in the province.

The original consultants, in their report, recommended a DEng programme with an industrial rather than research orientation, perhaps particularly for part-time students. The subcommittee has found this suggestion interesting and ACAP advises the universities to give it some consideration. Some of the universities commented on this recommendation in response to the original consultants' report. Ottawa's current comments indicate a study is underway, "investigating the local demand and the financial implications" of such a programme.

Recommendation C39

> It is recommended that civil engineering departments, particularly those in cities where a substantial number of engineers is employed, should consider establishing Doctor of Engineering programmes suitable as preparation for work in an industrial environment and with requirements compatible with part-time study.

The second general point concerns transportation, a field that both the original consultants and the Discipline Group recommend strengthening. The subcommittee noted that the universities' plans include appointments to be made in this field. ACAP concurs with the subcommittee that the universities concerned should discuss their plans in an effort to ensure that no unnecessary duplications or lacunae occur in offering this field for PhD education in the province. This recommendation is in no way an attempt to subdivide the field but rather an effort to make sure the three present programmes (and any new ones) do not expand in the same direction leaving part of the field uncovered.

Recommendation C40

> It is recommended that the Discipline Group arrange discussions amongst the concerned universities regarding the coverage of subfields of civil engineering doctoral study in transportation in Ontario.

UNIVERSITY RECOMMENDATIONS

Again, ACAP would reiterate that before it reached a conclusion about the recommendations for each university, the comments from the university were carefully considered. Changes in factual information pointed out by the universities were referred to the subcommittee which amended its report appropriately. It should be repeated that ACAP saw no reason to ask the subcommittee to reconsider its quality judgments.

In accordance with the COU recommendation, the subcommittee has accepted the position of the consultants that transportation and water resources fields should be receiving more emphasis and that less effort should be devoted to the field of structures.

Note that in this report (and in the amended version of the subcommittee report which is appended) the term "water resources" includes two subfields described by the subcommittee under the names "hydraulics" and "environmental engineering". The universities will now be discussed individually.

Carleton University

ACAP notes the response from Carleton University says that a report dealing with cooperation with the University of Ottawa cannot be written by December, 1975. We wish to point out that the report called for is a progress report, not a definitive statement on a form of joint undertaking. There is reason to question the quality of the programmes and to suggest that Carleton's programmes in geotechnical engineering and structures and Ottawa's geotechnical engineering programme are probably not capable of standing alone as suitable programmes for PhD education. As joint ventures, ACAP feels they would offer a good opportunity for PhD study. Consequently ACAP recommended a progress report on cooperation discussions between the two universities by December, 1975, as preferable to immediate appraisal and/or cessation of PhD enrolment. It is pointed out that the recommendation does not contemplate future doctoral work in structures at Carleton except as part of a joint venture; since the field of structures should be de-emphasized, any effort to operate an adequate independent programme at Carleton would not be justified.

Recommendation C41

It is recommended that Carleton University:

a) continue its doctoral programme in the field of transportation studies, making every effort to strengthen this group;

b) continue its collaborative doctoral programme with the University of Ottawa in the field of geotechnical engineering and, together with the University of Ottawa, formulate academic regulations that will tend to emphasize the responsibility of the whole group for the progress of each student;

c) initiate conversations with the University of Ottawa to develop arrangements for collaboration in the field of structures on the same basis as that described for geotechnical engineering.

It is recommended that the two universities report to COU by December, 1975, on the results to that time of the actions recommended in b) and c). It is recommended that if the report on b) is not satisfactory to COU, each university should then cease enrolling doctoral students in geotechnical engineering until such time as it has obtained a favourable appraisal for work in that field. It is recommended that if the report on c) is not satisfactory to COU, Carleton should cease to offer the PhD in the field of structures.

University of Ottawa

The University of Ottawa, in its response to the subcommittee's report, indicates that it can supply a statement on its cooperation with Carleton by the deadline suggested. The response also indicates that the University is considering a programme leading to a Doctor of Engineering degree and is reviewing its course offerings as listed in the calendar. The University sums up their comments by saying that they find the report "generally acceptable".

Recommendation C42

It is recommended that the University of Ottawa:

a) continue its doctoral programme in the field of water resources;

b) continue its collaborative doctoral programme with Carleton University in the field of geotechnical engineering and together with Carleton University, formulate academic regulations that will tend to emphasize the responsibility of the whole group for the progress of each student;

c) engage in conversations with Carleton University to develop arrangements for collaboration in the field of structures on the same basis as that described for geotechnical engineering.

It is recommended that the two universities report to COU by December, 1975, on the results to that time of the actions recommended in b) and c). It is recommended that if the report on b) is not satisfactory to COU, each university should then cease enrolling doctoral students in geotechnical engineering until such time as it has obtained a favourable appraisal for work in that field.

McMaster University

In their report, the subcommittee suggests that McMaster University might develop transportation as their second field at the PhD level. ACAP notes that McMaster's response indicates a preference for increased civil engineering emphasis on water research and therefore, the desire to develop water resources as their other doctoral field. This is not strongly at variance with the arguments of the subcommittee concerning McMaster's choice of a second doctoral field; the preference for transportation was marginal, and the main point was that a second field would be desirable at McMaster.

We cannot accept another point in McMaster's response; namely, the suggestion that geotechnical activities be included under structures. The distinction between the two fields is found throughout the consultants' report, and is considered to be important by Queen's, the only other university to discuss this point. At McMaster, PhD theses on geotechnical topics related to earthquake engineering are not ruled out by the exclusion of geotechnical engineering but, on the contrary, would be considered part of the structures programme. But geotechnical engineering is much broader than this and McMaster does not appear to be strong enough in the geotechnical engineering field as a whole to be able to offer geotechnical engineering PhDs per se; it does not now do so.

Recommendation C43

> It is recommended that McMaster University continue its doctoral work in civil engineering in the field of structures according to its plans and, as resources become available, develop doctoral work in another field, either water resources or transportation.

Queen's University

The Queen's University response suggests a number of factual changes in the subcommittee's report and where these are relevant and substantiated by the data available to ACAP, the corrections have been made. Queen's objects in particular to the section on its structures programme. The subcommittee found that as a field for doctoral education, its quality was questionable and therefore recommends that the programme go to appraisal. In its response, Queen's objects to the quality rating, asserting that the subcommittee failed to take into account the department's professional activity, particularly on the design of concrete highway bridges for the provincial government. Clearly one must consider the extent to which these professional activities support a PhD programme and whether they outweigh other apparent weaknesses. The subcommittee had doubts enough to recommend appraisal. ACAP carefully considered the statements from Queen's and data from three other relatively weak structure groups. ACAP considers that the request for an appraisal is justified.

Recommendation C44

> It is recommended that Queen's University continue its doctoral programme in civil engineering in the fields

> of hydraulics, geotechnical engineering, and structures according to its plans, strengthening the geotechnical group if possible and submitting the structures work for appraisal in the fall of 1977, ceasing to enrol new students in this field if the appraisal is not favourably completed by June, 1978.

University of Toronto

The University of Toronto response suggests that the subcommittee did not give sufficient attention to the concrete field in structures and to the transportation area, and therefore gave them a lower quality rating than they deserve. The subcommittee met with representatives from the university at which time additional information was presented. Although the university presented considerable additional material about the professional and research activity of the staff and about the support of the transportation field by members of other departments and institutes, the subcommittee did not feel that it should change its ratings. ACAP notes that a higher rating would not alter the recommendation. ACAP also notes that the subcommittee expects rather rapid change in this department, and that members of the subcommittee do not now feel it to be important to mention the planned additional appointments in the ACAP recommendation.

Recommendation C45

> It is recommended that the University of Toronto continue its doctoral programme in civil engineering in the fields of environmental engineering, geotechnical engineering, structures, and transportation according to its plans.

University of Waterloo

The University of Waterloo finds the subcommittee's report to be "generally acceptable" and raises two points in its response. The new data regarding the transportation group was examined and factual errors have been corrected in the subcommittee's report. ACAP notes the comments concerning the support provided to the geotechnical engineering group by professors now working in other fields. This shift of research interest will have developed further by the time the University submits this programme for appraisal.

Recommendation C46

> It is recommended that the University of Waterloo continue its doctoral programme in civil engineering, in the fields of structures, water resources, transportation and geotechnical engineering according to its plans, but that it submit the work in geotechnical engineering for appraisal in the fall of 1977, ceasing to enrol new students in that field if the appraisal is not favourably completed by June, 1978.

Universities of Western Ontario and Windsor

There are no recommendations concerning the Universities of Western Ontario and Windsor in this ACAP report. Their doctoral work in civil engineering fields was looked at by the subcommittee in order to get a complete picture of doctoral civil engineering education in the province. Their inclusion in the published quality assessment was at their request. Recommendations for these two universities concerning doctoral engineering programmes are found in the *COU Report and Recommendations concerning Doctoral Studies in Engineering* - Part 1, June, 1974.

Embargo Recommendation

Recommendation C47

> It is recommended that COU accept these recommendations and request the Minister to remove the embargo on doctoral work in engineering in accordance with his initial announcement in 1971 concerning embargo of graduate programmes, since this, together with COU's two earlier reports on engineering, completes the planning assessment.

APPENDIX 1

REPORT ON PhD PLANNING ASSESSMENT IN CIVIL ENGINEERING IN ONTARIO UNIVERSITIES

Submitted to the

ADVISORY COMMITTEE ON ACADEMIC PLANNING

ONTARIO COUNCIL ON GRADUATE STUDIES

by the

ACAP SUBCOMMITTEE ON CIVIL ENGINEERING

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January, 1975

INDEX

1. INTRODUCTION 1-1
1.1 Origin of Study 1-1
1.2 Scope of Study 1-2
1.3 Acknowledgments 1-2

2. GENERAL EVALUATION 1-3
2.1 Procedure 1-3
2.2 Objectives of PhD Education 1-3
Recommendation 1 1-4
2.3 Fields 1-4
2.4 International Stature 1-4
2.5 Specialization 1-5
2.6 Enrolment 1-6

3. ANALYSIS OF CURRENT SITUATION 1-11
3.1 Combined Statistics 1-11
3.2 Comment on Staff Qualifications 1-12
3.3 Quality Summary 1-12
3.4 Structures 1-13
3.4.1 University of Waterloo 1-13
3.4.2 McMaster University 1-13
3.4.3 University of Western Ontario 1-14
3.4.4 University of Ottawa 1-14
3.4.5 University of Toronto 1-14
3.4.6 University of Windsor 1-15
3.4.7 Carleton University 1-15
3.4.8 Queen's University 1-15
3.4.9 Quality Summary 1-15
3.5 Geotechnical Engineering 1-15
3.5.1 University of Western Ontario 1-16
3.5.2 Carleton University and the University of Ottawa 1-16
3.5.3 Queen's University 1-16
3.5.4 University of Toronto 1-17
3.5.5 University of Waterloo 1-17
3.5.6 Quality Summary 1-17

3.6 Water Resources 1-17
3.6.1 Queen's University 1-18
3.6.2 University of Waterloo 1-18
3.6.3 University of Ottawa 1-18
3.6.4 University of Toronto 1-18
3.6.5 University of Windsor 1-19
3.6.6 McMaster University 1-19
3.6.7 Quality Summary 1-19
3.7 Transportation 1-19
3.7.1 University of Waterloo 1-19
3.7.2 Carleton University 1-19
3.7.3 University of Toronto 1-20
3.7.4 McMaster University 1-20
3.7.5 Queen's University 1-20
3.7.6 Quality Summary 1-20
Recommendation 2 1-20

4. CARLETON UNIVERSITY 1-21
Recommendation 3 1-22

5. UNIVERSITY OF OTTAWA 1-24
Recommendation 4 1-24

6. McMASTER UNIVERSITY 1-26
Recommendation 5 1-27

7. QUEEN'S UNIVERSITY 1-28
Recommendation 6 1-28

8. UNIVERSITY OF TORONTO 1-29
Recommendation 7 1-30

9. UNIVERSITY OF WATERLOO 1-31
Recommendation 8 1-31

ADDENDUM 1-32

1. INTRODUCTION

1.1 Origin of Study

A planning assessment of doctoral work in engineering was carried out under the instructions of the Council of Ontario Universities in a manner described on pages 8 - 12 of the preceding ACAP report of June 7, 1974.[1] On the basis of the material available to ACAP at that time, including consultants' reports, it was possible for COU to make recommendations constituting an Ontario university system plan for doctoral work in chemical engineering, electrical engineering, mechanical engineering, metallurgical and materials engineering, mining engineering, and industrial engineering and systems design. It was, however, unfortunate that the report from the civil engineering consultants did not contain the basis for a similar set of recommendations for that subject. This difficulty is discussed on pages 30 - 35 of the ACAP report of June, 1974.[1] In short, although the consultants' report contained a good deal of valuable material of a more general character, it did not present much detailed discussion and evaluation of doctoral work in the individual civil engineering departments. Consequently, COU instructed ACAP "to examine the available documentation on civil engineering, to reach its own judgments on the basis for a report, after soliciting assistance from the Discipline Group and the universities, and to prepare its report to COU containing recommendations for the future of civil engineering doctoral work." Recommendation 15 in the COU report of June, 1974, indicates that this report should "deal adequately with the future role of each department in respect to the different fields of doctoral research, paying particular attention to the relative strengths and weaknesses of each department and the change in emphasis on fields recommended by the consultants."[2]

In considering how to carry out this task, ACAP came to the conclusion that the work should be done in the first instance by a special subcommittee consisting of its engineering subcommittee increased to include an engineer from outside the Ontario university system. This additional member would play exactly the same role as other members of the special subcommittee, participating fully in all meetings. He would be chosen by ACAP after giving CODE an opportunity to react to a list of nominees. This suggestion was approved by OCGS and COU in June, 1974, and, after consultation with CODE, ACAP was pleased to secure the agreement of Dean Grenier to serve on the subcommittee.

OCGS and COU also approved the following procedure:
"The subcommittee will prepare a report to ACAP. This report will be circulated for comment to the universities and to the Discipline Group in much the same way as a consultants' report is. ACAP as a whole will then write a report which will have as appendices the report of this subcommittee, and the comments of the universities and of the Discipline Group."

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1. Report of Advisory Committee on Academic Planning, June, 1974.
2. Report and Recommendations of the Council of Ontario Universities, Part 1, June, 1974.

The subcommittee met on September 24, 1974, and decided to request certain updated information from the universities. Essentially, this consisted of a description of changes in the composition of the faculty, additions to CV's already on file, reports on enrolments and other characteristics of the graduate student bodies, descriptions of recent research grants, revisions if any to the five-year plans already submitted, and any other statement that the universities might consider helpful. Most universities met the deadline of November 1 for submitting these data which were then provided to the members of the subcommittee. The subcommittee then met on December 11 and 12 during which time it held a meeting with the Discipline Group, and individual meetings with the chairman of each department about which this subcommittee was asked to make recommendations. Substantial progress on preparation of its report was also made at this time and the report was completed by correspondence and by further meetings in January, 1975.

1.2 Scope of Study

As the instruction from COU implied, a number of the general COU recommendations were supported by the original consultants' report and it would not be necessary to re-examine these. In particular, the COU report of June, 1974,[2] lists a number of actions taken by COU, of which the first six deal largely with enrolment and employment, admission standards, mobility of students, and time involvement of students. All of these would apply equally to civil engineering. Similarly, the first five recommendations in the COU report are of general application.

The specific task of the subcommittee was to make recommendations concerning the future of the doctoral programmes at Carleton, McMaster, Ottawa, Queen's, Toronto and Waterloo.

Two universities, Western Ontario and Windsor, offer doctoral work with research in fields usually found in civil engineering departments but both of these universities are dealing with doctoral work in engineering on an interdisciplinary basis that cuts across the traditional departmental lines. Recommendations 6 and 7 of the COU report[2] deal with the totality of engineering doctoral work in these two universities and it is, therefore, inappropriate for the report of the subcommittee to contain recommendations concerning these two institutions. On the other hand, it was necessary for the subcommittee to have some knowledge of the relevant research areas available to doctoral students at Western and Windsor because they do constitute a part of the total picture of the activities of the provincial system. The subcommittee is grateful for the participation of the representatives of these two universities in the meetings of the Discipline Group and for the information they have provided to the subcommittee.

1.3 Acknowledgments

The subcommittee acknowledges with gratitude the cooperation of the universities in promptly providing additional information and, in particular, the cooperation of the chairmen in the meetings on December 11 and 12.

2. GENERAL EVALUATION

2.1 Procedure

The subcommittee was conscious of the fact that COU had asked it to make a detailed report on certain aspects of doctoral work in civil engineering departments, even though the subcommittee differed from a team of consultants in that its members were not civil engineers. It realized that it was the view of COU that such a group could satisfactorily perform the somewhat limited task assigned, using as a basis the original consultants' report, the data available to them, updated as described and with help from the Discipline Group, and from the individual department chairman.

At the Discipline Group meeting the subcommittee requested discussion of objectives of doctoral training in civil engineering, desirable characteristics of PhD supervisors for civil engineering, the relative importance of refereed publications and the place of conference proceedings in evaluating a faculty member's research activity, the international stature of Ontario civil engineering research, and the role of specialization in doctoral study for smaller departments. At the request of the Discipline Group enrolment forecasts were also discussed. The subcommittee found that the views of the Discipline Group on these questions were very helpful.

It was possible to obtain reasonably detailed pictures of the doctoral programmes within each department in the courteous and candid interviews with the department chairmen. The committee also had available to it complete details of enrolment for six years, professors' CV's, publication lists and research grants, descriptions of physical facilities, graduate calendars, etc. The members of the subcommittee, with the exception of Dean Grenier, had prepared the ACAP report on engineering and were therefore familiar to a considerable extent with the standards, problems and achievements of the other engineering disciplines. Dean Grenier, of course, is the leader of a respected engineering faculty and had acquired a recent intimate knowledge of doctoral study in chemical engineering in Ontario as an ACAP consultant.

2.2 Objectives of PhD Education

Of the various branches of engineering, civil is the one which most recently has developed a substantial amount of doctoral level research in North America. It is therefore not surprising if it is in this subject that the dichotomy is most extreme between research activity on one hand and professional training on the other. The members of the Discipline Group were in agreement that ideally a PhD graduate in civil engineering should show both a capacity to solve advanced professional problems and an ability to carry out original research. There was general agreement that he should be quite flexible as to the type of problem he would be willing to tackle; this would imply considerable breadth in his graduate training. Some members expressed the opinion that the courses taken for master's degrees would provide much of this breadth, but others maintained that the master's programme for an intending doctoral student should emphasize a research thesis.

There was apparent agreement that the most satisfactory preparation for doctoral work was two or three years of industrial experience, preferably in research and development, but the practical problems of returning to full-time study were stressed. The subcommittee considers these views of the Discipline Group appropriate in the present circumstances, but holds that in the course of some years there may be less justification to insist on equal emphasis on research and professional aspects.

There have been suggestions from time to time that if an engineer preparing for an industrial career is to devote three or four years to post-graduate university work it would often be the case that the most useful curriculum would be something markedly different from the current PhD requirements. The title Doctor of Engineering has been suggested. The original consultants' report recommended the establishment of such a programme, and some members of the Discipline Group showed an interest in this suggestion. Although this recommendation would appear to have broader applications in engineering, it may be that civil engineering is the area in which there would be greatest current interest. As we will see, there is a marked decline in doctoral enrolment, at least in part due to the very attractive employment opportunities for persons with bachelor's degrees. Perhaps the opportunity to pursue graduate work with a more professional slant would aid in alleviating this problem. We therefore repeat the consultants' recommendation.

Recommendation 1

> It is recommended that civil engineering departments, particularly those in cities where a substantial number of engineers is employed, should consider establishing Doctor of Engineering programmes suitable as preparation for work in an industiral environment and with requirements compatible with part-time study.

2.3 Fields

Four broad fields of civil engineering are recognized in this report: structures, geotechnical engineering including soil mechanics, water resources, transportation. Each of these fields will be discussed in a separate section. The original consultants' report recommended that, in general, the field of structures be somewhat de-emphasized and that more doctoral work be encouraged in water resources and transportation. Paragraph 3.1 shows that well over half of the PhD students are in the structures field. While we recognize that historically structural engineering was the most important part of typical graduate programmes in civil engineering there are indications that an increasingly urban society is facing problems whose solution will demand increasing engineering expertise in the field of transportation and water resources. The Discipline Group supports this view, and the plans of most of the universities reflect it.

2.4 International Stature

During discussion with the Discipline Group, the view emerged that the province has no department which, as a whole, would rank amongst the top six in North America as a place to do doctoral work, but that one of the departments would be found somewhere in the second six. On the other hand, looking at individual fields the structures group at Waterloo is thought to be comparable with the best in the world. In addition there are at least three other groups in the province which might be characterized as very good and having international visibility. Thus, although civil engineering in Ontario presents opportunities which would attract the very best students, there is a case for deliberately seeking to strengthen the work in some fields. A more detailed discussion is given below.

2.5 Specialization

In considering recommendations about specialization at each university, we have of course taken account of the extent of the specialized activity throughout the province. In our opinion, the quality of education available to a PhD student in a given department is influenced primarily by the available faculty in his field. In making the judgments in this report we have considered both the number of faculty and the extent to which they meet the criteria desirable for thesis supervisors as discussed with the Discipline Group. We have also borne in mind the desirability that there be faculty to advise students and give courses in areas contiguous to the field in question.

It was not suggested to us that there were any serious limitations placed on the current programmes by shortage of space or other inadequacies in physical facilities.

Since there was earlier considerable discussion in the engineering community about the concept of "critical size", it may be well to indicate that the subcommittee has based its considerations on the principle formulated by COU: "The quality of graduate programmes is partly dependent on size, and for each programme, depending on how it is designed and its scope, there is a minimum size of enrolment below which quality may suffer. That number cannot be expressed for the discipline as a whole but only for individual programmes depending on their purpose, their resources and their design."

The subcommittee has therefore proceeded in this individualistic way when necessary. It should, however, be said that its recommendations are based much more on its perception of faculty size and quality than on enrolment numbers.

Most civil engineering departments see their major role as the training of undergraduates. Consequently, even the smallest departments need staff members capable of instructing in each of the major fields. Furthermore, it is clearly difficult to expose a graduate student to the breadth of training desired by the Discipline Group if there are active professors in only one field. We therefore would suggest that a department should attempt to maintain research activity in at least two fields.

In order to be effective in teaching, a faculty member must be involved in research or advanced professional practice. One of the ways in which professors carry out research is in collaboration with graduate students. While this method has some advantages, it is by no means the only possibility. It seems to the subcommittee that many engineering professors are in a particularly good position to remain active in research and professional involvement without graduate students, through consulting and by contract funding for research of practical interest.

2.6 Enrolment

The enrolment of doctoral students in civil engineering is decreasing. Numbers are given in Table 1 and in Figures 1 and 2[3]. It can be seen that the decrease up to the present has been concentrated in two universities - Waterloo and Queen's. The peak year for total doctoral enrolment was 1971-72 when there were 144 students enrolled. In 1974-75 the number is 104. Of this decrease of 40, Waterloo and Queen's together account for 35. The current enrolment contains only 65 full-time students; together with the part-time students, this leads to an equivalent full-time enrolment of 78 in six departments. The original consultants' report recommended 80 to 90 for this number; in doing so they were calling for a 20% reduction from the enrolment in 1971-72. Since there is a general feeling that they may have underestimated the total need for PhDs, particularly in transportation and water resources, it can be argued that the current enrolment is too low. In fact, it seems clear that it will drop still further, since the number of new doctoral students beginning their studies this fall was only about 15.

It is important to examine the number of Canadian citizens enrolled. This number was 40 in 1969-70, rose to 53 in 1971-72, and is now 38. The new intake in 1974 was about 10. If the downward trend in the number of Canadians were to continue one would expect a further decrease in enrolment to the low thirties.

The subcommittee worried about the problem of mobility of graduates from Canadian universities but the numbers are too small to draw conclusions.

The average number of degrees awarded during the last five years has been 23 per year. To maintain this level in a steady state situation would involve an annual entry of, say, 28 students and this corresponds to a full-time equivalent enrolment of around 90.

The above numbers appear to substantiate the claim of the Discipline Group that there is a dangerously low enrolment if society is to have the necessary number of engineers with advanced training. It is also true that the decrease in doctoral enrolment is delaying some research projects whose immediate utility is testified to by the provision of ample grants and contracts, but as we have suggested above it may be inescapable that means be found to facilitate research without graduate students.

It is asserted that the employment opportunities for people with bachelor's degrees in engineering are so attractive that the current income level for graduate students causes even the best students to decide against research-oriented graduate study.

The high percentage of students leaving at the bachelor's level suggests that society's future need for engineering personnel with graduate training may not be met. Perhaps the employers are no fully aware of the value of an

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[3] The students at Western and Windsor (approximately 15) are not included in the Table or Figures.

Table 1

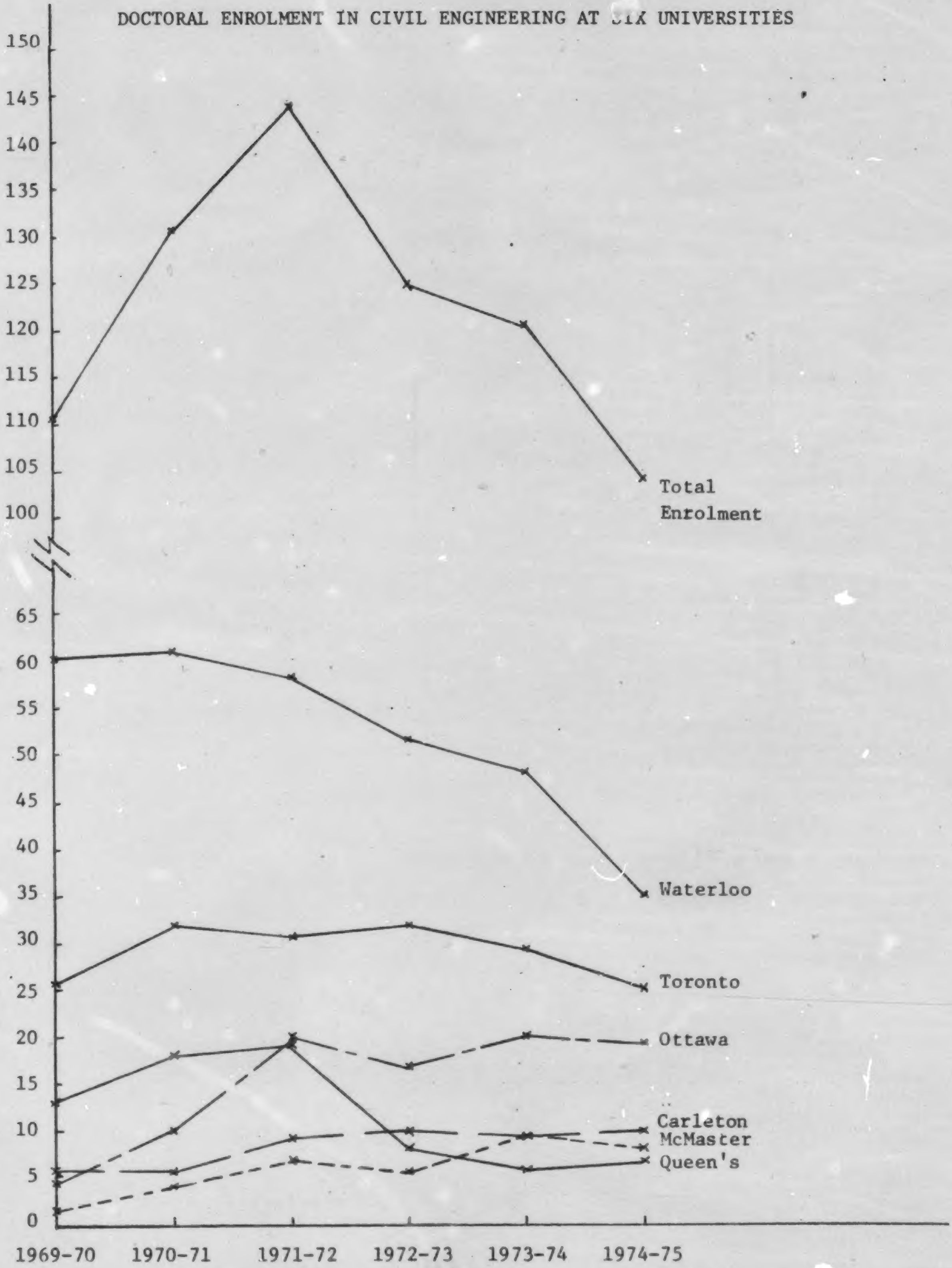
DOCTORAL ENROLMENT IN CIVIL ENGINEERING IN ONTARIO

(6 Universities)

Year	All Students			Canadian Citizens			% Total Canadian Citizens / Total All Students		
	Total	FT	PT	Total	FT	PT	Total	FT	PT
1969-70	111	96	15	40	31	9	36	32	60
1970-71	131	106	25	49	34	15	37	32	60
1971-72	144	112	32	53	33	20	37	29	63
1972-73	125	100	25	34	20	14	27	20	56
1973-74	121	90	31		*				
1974-75	104	65	39	38	16	22	37	25	56

*Data not available for this year.

Figure 1

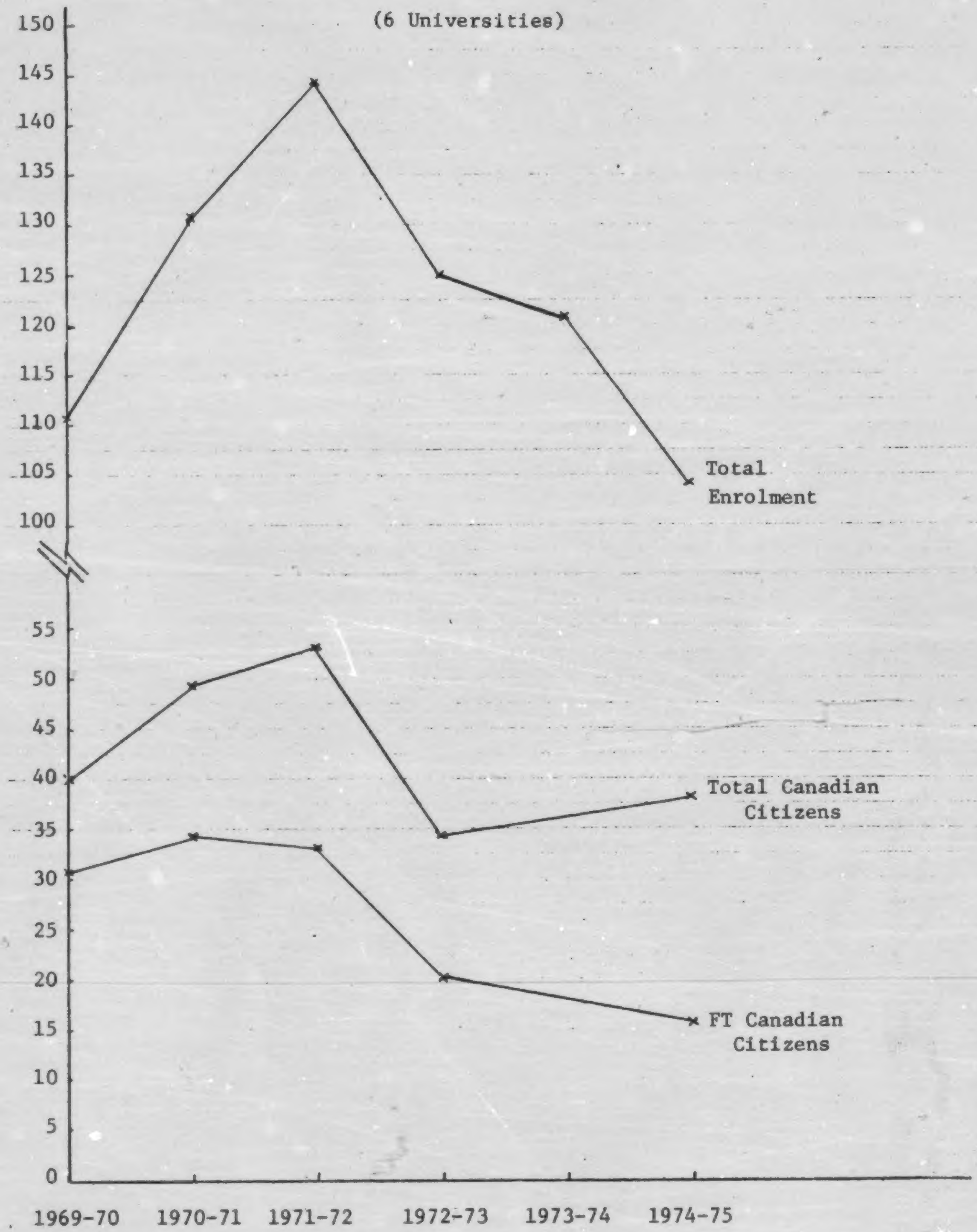


DOCTORAL ENROLMENT IN CIVIL ENGINEERING AT SIX UNIVERSITIES

Figure 2

CANADIAN COMPONENT OF DOCTORAL ENROLMENT IN CIVIL ENGINGEERING

(6 Universities)



engineering doctorate. The realization of the role a PhD can play in industry or government is the ultimate goal in a plan to raise the number of Canadians in advanced engineering study. If the need for a PhD was felt and the financial support levels were raised, increasing numbers of Canadians might stay for further training. The Discipline Group feels constrained by the upper limits of support they may offer prospective doctoral students. They would like to see the scholarships raised to about $7,000 with the option to use contract monies to supplement a student's income.

The COU report contains three recommendations which speak specifically to this whole problem of declining doctoral enrolment. These call for a substantial effort to inform students of the value of a PhD in many phases of government and industry, to maintain the Canadian and Landed Immigrant content of the doctoral programme, to consider the extent to which student income deters Canadians from entering graduate work, and to discuss with employers steps to be taken jointly to overcome the shortage of Canadian students.

These recommendations apply to all fields of engineering, but it may be that the last point is of particular significance in civil engineering where non-academic employers may not be as convinced of the value of a PhD to their activities. It is partly with this in mind that we have recommended consideration of an alternative form of doctoral work.

Although it seems important that the recommendations made by COU be actively pursued, it also seems clear that they cannot have much immediate effect. The subcommittee would therefore advise universities to expect a further drop in civil engineering doctoral enrolment for the next year or two. Naturally this drop would not necessarily occur uniformly in the six departments.

3. ANALYSIS OF CURRENT SITUATION

3.1 Combined Statistics

University	Category	Total		Structures		Geotech.		Hydraulics & Wat. Res.		Transp.	
		FT	PT	FT	PT	FT	PT	FT	PT	FT	PT
Carleton	Master's	11	28	5	12					6	16
	PhD	6	4	2	1	1				3	3
	PDF	0									
	Faculty	12	1	7	1	1				4	
McMaster	Master's	24	38	12	26			9	6	3	6
	PhD	6	2	6	2						
	PDF	1		1							
	Faculty	13		7		2		2		2	
Ottawa	Master's	17	11	7	5	6	5	4	1		
	PhD	11	8	4	3	2	4	5	1		
	PDF	0									
	Faculty	15	4	6	1	4	1	5	2		
Queen's	Master's	25	12	8		9	4	7	3	1	5
	PhD	5	2	2	1	3			1		
	PDF	0									
	Faculty	18		5		3		7		3	
Toronto	Master's*	54	79	22	43	8	7	8	15	14	12
	PhD	15	10	7	6		2	6	1	2	1
	PDF	0									
	Faculty	25½		12		5		4½		3	1
Waterloo	Master's	47	15	23	7	4	2	7	6	13	1
	PhD	22	13	13	7		2	6	2	3	2
	PDF	3		3							
	Faculty	36	2	20	2	3		6		7	
Western	Master's	8	2	4	2	4					
	PhD	5	4	3	3	2	1				
	PDF	0									
	Faculty**	7		4½		2½					
Windsor	Master's	7	12	4	8			3	4		
	PhD	2	2	1	1			1	1		
	PDF	0									
	Faculty	11	1	7	1			4			

*There are 2FT and 2 PT Master's in Surveying.
**Research professors not included.

3.2 Comment on Staff Qualifications

The Discipline Group identified a number of desirable qualities for doctoral thesis supervisors. The subcommittee is in agreement. Ideally, a supervisor should:

- have a PhD or equivalent research experience
- have experience of supervising master's students
- be professionally experienced, e.g. as a consultant
- display intense research activity as evidenced by publication record, grants received, theses directed, contracts fulfilled, etc.
- have a natural disposition to be available to students and to communicate easily with them.

These qualities become more difficult to assess as one goes down the list. It was impossible for the subcommittee to assess the last characteristic but as a proxy one could look at the number of doctoral students who had completed degrees with the professor.

On the matter of publications the Discipline Group stressed the importance of looking at the trend over the last few years, particularly in refereed journals. The Discipline Group collectively as well as the individual chairmen, also indicated that publication in conference proceedings has quite variable significance as an indicator of research activity. Apparently one has to know a good deal about the auspices and refereeing policy of each conference or conference series. The chairmen helped us in some cases with this evaluation.

3.3 Quality Summary

On the basis of the information available to the subcommittee, both in documentary form and in the interviews with the chairmen, we have decided to evaluate each field at each university on a four-point scale. It will be realized that the descriptions of each group given below are only concise summaries of the material examined. The four categories selected are:

- Outstanding (comparable with the best in the world)
- Excellent (e.g. one of the best four or five in Canada with some international recognition)
- Satisfactory (competent to good, e.g. there would be little or no hesitation in advising a good student to enter the programme)
- Questionable (either the quality is inadequate or further study is required to establish its adequacy)

It should be clearly understood that these evaluations apply solely to suitability for the training of PhD students and do not have any necessary relationship to undergraduate programmes, to other kinds of graduate work, or to professional activity of the teaching staff. To be considered outstanding (comparable to the best in the world) it would be clearly necessary that the group have very considerable breadth in its research interests. A smallish group may contain individual professors whose research is of the highest calibre but the group would not fit our definition of the outstanding category if the scope of the programme is limited.

3.4 Structures

Doctoral students in structures are found in all six departments - indeed in all eight engineering faculties. This has been the most popular field of civil engineering and, while it remains important, it may be desirable to reduce the emphasis on it in some schools.

3.4.1 University of Waterloo

The structures group at Waterloo contains about 17 faculty members active in research and supervision of graduate students. Of these, 10 are professors, 5 are associate professors and 2 are assistant professors. Publication is extensive, amounting to some 76 papers in refereed journals in the last two years. The group of course has grants and contracts from a variety of sources, but it is worth noting that the average NRC personal operating grant is $10,600[4]. There are 20 doctoral students enrolled in this group; two years ago it had about 35. Also in 1974-75 the group contains 30 master's students and 3 post-doctoral fellows. In recent years this group has graduated in the order of 10 PhDs per year.

The subfields for thesis topics are structural engineering, applied mechanics, materials science and experimental mechanics.

3.4.2 McMaster University

Structures is the only field in which McMaster currently offers the PhD. The group contains 7 faculty members active in structures research and currently supervising graduate students. Of these, 3 are full professors, 3 are associate professors and 1 is an assistant professor. (The assistant also devotes some of his time to geotechnical engineering.) Publication is good, with some 20 or 25 papers in refereed journals in the last two years. Research grants are predominatly from NRC and the average personal operating grant is $10,600. There are 8 doctoral students in the group. There are also 38 master's students and a post-doctoral fellow. The doctoral enrolment has been fairly steady during the last few years but the master's enrolment has increased. The group has graduated 6 PhD students in 5 years.

The McMaster group concentrates its research on earthquake engineering. Three of the members of the group list this specifically as their specialty and, although others specialize in concrete structures, composite structures, plasticity, and elasticity, a good deal of the work in these other fields is related to earthquake research. The group has international visibility. Experimental and theoretical expertise is well balanced in the group.

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[4] NRC grants quoted are for 1974-75.

3.4.3 University of Western Ontario

The group at Western might well be called structures and industrial aerodynamics, since most of its activity is associated with the boundary layer wind tunnel laboratory. The core of the group contains 2.5 professors, an associate professor and an assistant professor. There are also two research engineers with faculty status and two faculty members from other departments. There is considerable publication for the size of the group in refereed journals, technical reports and conference proceedings. The wind tunnel work is very well funded in the form of grants and by industrial contracts. There are 6 doctoral students enrolled. In the last 4 years the group has graduated 5 PhD students.

The subfields for theses include both design methodology and more basic research centred around the use of the wind tunnel. The international recognition of the wind tunnel group is demonstrated by their involvement in the design of the CN tower (Toronto), the Bank of Montreal Building (Toronto), Federal Reserve Bank (Boston), long span bridges (New York and Pennsylvania), the world's largest gantry crane (Sweden) and others.

3.4.4 University of Ottawa

The structures group (as distinct from the geotechnical group) at Ottawa consists of 1 professor and 2 associate professors in the Department of Civil Engineering, with support from certain members of the Department of Mechanical Engineering. The 3 members of the civil engineering department publish actively (8 refereed papers in two years) and have an average NRC grant of $9,300. There are currently 4 PhD candidates and 4 master's candidates working with these three faculty members and 3 other PhD students are supervised by professors in mechanical engineering. The experimental work is in reinforced concrete, shoring systems and civil engineering materials.

3.4.5 University of Toronto

We will discuss in this section the structures and materials work in the University of Toronto civil engineering department. The number of faculty members active in research and graduate student supervision can be put at 9 in structures and 3 in materials. These include 4 professors, 7 associate professors and an assistant professor. The publication record of the group is adequate but not outstanding, consisting in the last two years of 31 items, of which 5 or 6 are research articles in refereed journals. The average NRC personal operating grant is $6,500. (This includes 4 staff members who do not receive grants. If they are excluded the average is $9,800.) There are at present 13 doctoral students in structures and materials. There are also 65 master's students. The enrolment is noticeably less at both levels this year than it was in 1973-4.

The subfields in which professors in this group do research are rather varied and include concrete structures and materials, steel, experimental structural analysis, computer analysis, optimization in structural design, and composite materials.

3.4.6 University of Windsor

The structures group at Windsor contains 7 faculty members who supervise graduate students and one of these works in soil mechanics. There are 2 professors, 3 associate professors and 2 assistant professors. Publication is reasonable, with some 16 papers in refereed journals in a two-year period. Research funding reported for the current year is entirely from NRC and the average personal operating grant is $8,900. There are at present only 2 doctoral students enrolled, although two years ago the number was 7. The group also has 12 master's students, 8 on a part-time basis. Four PhD degrees were awarded in the two-year period 1973 and 1974.

During recent years research has involved work on metal and composite shells and slabs, bridge structures and construction, properties of concrete and of steel and analysis of structural systems.

3.4.7 Carleton University

Of the faculty at Carleton with a background in structures (as distinct from soil mechanics) 3 have research grants and graduate students. One is a professor and the other two are associate professors. Their average NRC operating grant is $6,800. At present only one of them is supervising a doctoral student. The main research activity is in structural analysis, both of steel and reinforced concrete structures.

3.4.8 Queen's University

The structures group at Queen's now consists of 5 faculty members - one professor, two associate professors and two assistant professors. One of the assistant professors is newly appointed, having just completed his own doctorate. The publication activity of the group in refereed journals is low and the average NRC operating grant for the three members who have grants is $5,800. On the other hand, two members of the group are very active in contract activity for the Ministry of Transportation and Communications, doing research and design on highway bridges. The other current field of research is polymer concrete. Although Queen's has graduated 13 people with PhDs in structures, the current doctoral enrolment is 3, and there are 8 master's candidates.

3.4.9 Quality Summary

Using the notation explained in paragraph 3.3, the programmes in structures are categorized as follows with regard to the suitability for the training of doctoral students:

Carleton - Questionable,
McMaster - Excellent,
Ottawa - Satisfactory,
Queen's - Questionable,
Toronto - Satisfactory,
Waterloo - Outstanding,
Western - Excellent,
Windsor - Satisfactory.

3.5 Geotechnical Engineering

Geotechnical engineering, including soil mechanics, is often considered a part of the structural field and in some cases the interests of faculty members in the two areas are sufficiently close that it is realistic to think of them as forming one group from the point of view of graduate training.

On the other hand, some universities think of them as distinct. Geotechnical work in civil engineering is not nearly as fully developed as is structures. We shall describe the geotechnical work in each institution.

We have already noted that Windsor has only one faculty member who does research in soil mechanics. McMaster has two, one of whom devotes only a fraction of his research time to geotechnical questions and the university does not offer this as a field for doctoral theses.

3.5.1 University of Western Ontario

The group in geotechnical engineering at the University of Western Ontario consists of three full professors, all of whom publish actively. A little more than half of their research funding is from NRC and the average NRC operating grant is $16,200. The group normally has six to ten graduate students and two research associates or post-doctoral fellows. Since 1970 six PhDs have been awarded.

The group appears to have a close relationship involving doctoral students with the geology department and with the biochemical engineering group. The research areas are soil mechanics, rock mechanics, engineering geology, mineralogy, foundation dynamics, and mathematical techniques.

3.5.2 Carleton University and the University of Ottawa

The cooperation between Carleton University and the University of Ottawa in geotechnical engineering amounts to an amalgamation of their resources. The programme also depends strongly on cooperation from the Mining Research Centre of the Department of Energy, Mines and Resources and of the National Research Council. The group contains three full-time faculty members at the University of Ottawa, one at Carleton University, and two part-time professors from government laboratories, as well as a member of the geography department at Carleton and one from the Department of Mechanical Engineering at Ottawa. Collectively, the group has a reasonable publication record. Four of the engineering professors have NRC grants which average $6,600. Currently 18 graduate students are enrolled in the two universities, seven of whom are PhD candidates.

The group has done research in soil mechanics and rock mechanics. There is an interest in developing work in permafrost engineering, but no full-time faculty members work in this field. (Since it is a new field, it would seem that it should be referred to the Appraisals Committee to consider whether an appraisal is necessary.) There is a close working relationship with the geology department at Ottawa and, as already noted, with the geography department at Carleton.

3.5.3 Queen's University

The geotechnical group contains three faculty members - one in each of the professorial ranks. All three are active in research and supervise graduate students and each has a good publication record. The average NRC grant is $9,900, but of course the assistant professor is still on the NRC "starting" grant. There are three PhD students and 13 master's students and one research associate. Five PhDs have been awarded since 1970.

There is a close relationship with the geology department, geology professors being on most supervisory committees.

The research fields lie in soil mechanics and are more particularly described as stress-strain behaviour, theories of consolidation and field permeability related to actual construction cases, influence of repeated loadings, influence of frost heaving, permafrost and performance of railroad track ballasts and fills. There is substantial research support for this latter activity through the Canadian Institute of Guided Ground Transport.

3.5.4 University of Toronto

The geotechnical group at Toronto contains two professors, an associate professor and two assistant professors. The three more senior people work in soil mechanics and the other two cover geological engineering and rock mechanics. The three senior members show good publishing activity; their research support is from the National Research Council and the operating grants average $10,000. There are at present 2 part-time doctoral students and 15 master's students.

There is extensive interaction with the geology department and with metallurgical engineering.

3.5.5 University of Waterloo

The geotechnical engineering group at Waterloo consists of three associate professors. Their outside research grants from NRC and Department of Energy, Mines and Resources total $11,500. A full professor also devotes perhaps half his time to this field, but at present has no students in it. At present, one doctoral student is enrolled in this field, but there have been as many as five in recent years.

Current activities include studies of the yielding of soils, settlement of structures, model testing, seepage and engineering geology.

3.5.6 Quality Summary

Using the notation explained in paragraph 3.3, the programmes in geotechnical engineering are categorized as follows with regard to the suitability for the training of doctoral students:

Ottawa - Carleton - Satisfactory, Queen's - Satisfactory,
Toronto - Satisfactory, Waterloo - Questionable, Western - Excellent.

3.6 Water Resources

This field of civil engineering has two major subfields. The one that we refer to for brevity as hydraulics includes fluid mechanics, hydrology, coastal engineering, erosion studies and related matters. We shall use the term "environmental" to refer to water quality, pollution control, and sanitary engineering. One or both of these subfields is available as a doctoral thesis area at five of the universities.

This is one of the fields on which greater emphasis should be placed at the doctoral level in the Ontario universities.

3.6.1 Queen's University

In doctoral training the emphasis at Queen's lies entirely in hydraulics. The group consists of seven faculty members engaged in research and graduate study, five of them professors and two associate professors. Publication is satisfactory, consisting of a book, 8 refereed articles and 12 conference contributions in the last two years. The average NRC operating grant is $7,200. At present there is one doctoral student but there were 7 in 1971-72. There are also 10 master's students in the group. Since 1962 there have been 14 PhDs awarded.

The principal specialty has been wave action, harbour design and other aspects of coastal engineering in which the group has an international reputation. There is also work on the transport of sediment and ice mechanics.

3.6.2 University of Waterloo

Waterloo offers doctoral opportunity in both subfields of water resources. There are 6.5 faculty members involved - 2 professors, 3 associate professors and 2 assistant professors. The publication record is strong - there are 25 articles in refereed journals in the past two years. All but the newly appointed assistant professor hold NRC grants of average value $7,500. In addition, there are grants from other agencies totalling $40,000. There are 8 PhD candidates and 13 master's students. Students have had to be refused admission because the number of staff is limited.

The areas for research topics are described as water resources system planning, hydraulics and hydrology, water pollution and sanitary engineering.

3.6.3 University of Ottawa

The water resources group at the University of Ottawa consists of three associate professors and two newly appointed assistant professors. There is also a full professor who devotes perhaps ten percent of his research time to this field. The group has an adequate recent publication activity and the average NRC grant of the associate professors is $6,300. There are six doctoral students and five master's students. In the past, this group has awarded three PhD degrees.

3.6.4 University of Toronto

The Toronto group works almost exclusively in the environmental subfield. It consists of 1.5 full professors and three associate professors. The group is publishing actively. The majority of its funding is from sources other than NRC and totals about $50,000. There are seven doctoral students and 23 master's students, of whom 15 are part-time.

The emphasis of the group is water quality. It has some cooperation with chemical engineering and mechanical engineering on specific projects.

3.6.5 University of Windsor

The group at Windsor is equally divided between hydraulics and water treatment. It consists of three full professors and one associate professor. All are publishing. Their research funding is entirely from the National Research Council and the average operating grant is $8,100. There are two doctoral students and seven master's students.

3.6.6 McMaster University

McMaster does not offer a PhD in this area. Two associate professors in civil engineering supervise 15 master's students, six of whom are part-time. The chemical engineering department offers doctoral work in water quality and water treatment.

3.6.7 Quality Summary

Using the notation explained in paragraph 3.3, the programmes in water resources are categorized as follows with regard to the suitability for the training of doctoral students:

Ottawa - Satisfactory, Queen's - Excellent Toronto - Satisfactory,
Waterloo - Excellent, Windsor - Satisfactory.

3.7 Transportation

Transportation engineering is offered as a doctoral field at only three universities - Carleton, Toronto and Waterloo. The original consultants recommended strengthening this activity.

3.7.1 University of Waterloo

The transportation group consists of five faculty members - two professors, two associate professors, and an assistant professor. The publication activity is good - there have been some 30 items in the last two years. Four members of the group have NRC grants, with an average value of $10,200. There is also substantial support from other sources. There are five doctoral students in the group which also contains 14 master's candidates. The group has been graduating about one PhD student per year.

Thesis projects may be in the fields of transportation planning, traffic analysis, urban transportation, land use and urban development, airport engineering, highway design, pavement structural design and transportation economics. However, the emphasis of the group has a distinct planning bias, and there is a close working relationship with the School of Urban and Regional Planning.

3.7.2 Carleton University

The transportation group consists of three associate professors and an assistant professor. The publication activity is reasonable. The average NRC operating grant is in the region of $6,500. There are six PhD students and 22 master's students, of whom 16 are part-time. It may also be noted that three of the PhD students are part-time.

The group stresses planning and analysis of transportation systems and considers technological, sociological and economic aspects. There is also some work on ground vehicle technology.

3.7.3 University of Toronto

The transportation group at Toronto consists of a professor (at present, part-time), two associate professors and an assistant professor. One member of the group works on highway engineering and has substantial grant support from the Ministry of Transportation and Communications. The others are interested in transportation planning and analysis. One of them has an NRC grant. There are three PhD students and 26 master's students, of whom 12 are part-time.

3.7.4 McMaster University

McMaster does not offer the PhD in transportation but has an enrolment of nine master's students, six of whom are part-time. This work is the responsibility of two assistant professors, one of whom has a joint appointment with the Department of Geography.

3.7.5 Queen's University

Queen's does not offer the PhD in transportation but has an enrolment of five master's students. This work is the responsibility of effectively two faculty members.

3.7.6 Quality Summary

Using the notation explained in paragraph 3.3, the programmes in transportation are characterized as follows with regard to the suitability for the training of doctoral students:

Carleton - Satisfactory, Toronto - Satisfactory, Waterloo - Excellent.

Since there is little work done in transportation in the province and the student enrolment is low we recommend strengthening this field. Several universities have indicated that they intend to make new faculty appointments and we suggest preliminary discussions involving these universities.

Recommendation 2

> It is recommended that the Discipline Group arrange discussions amongst the concerned universities regarding the subfields in which the proposed transportation appointments be made.

4. CARLETON UNIVERSITY

The discussions of the different fields in Chapter 3 indicate that the relatively small civil engineering group at Carleton has an adequate PhD offering in transportation, a rather weak offering in structures, and, together with the University of Ottawa, offers work of satisfactory standard in geotechnical engineering.

The department is able to grow in size. The subcommittee was informed that there is still authorization for three positions. There has been a steady increase in interest in master's study in transportation in recent years and it is therefore intended that one of the new faculty members be in this field. Carleton is also moving towards establishing a programme in building design and construction. This will be introduced in the first instance at the undergraduate level and progressively expanded into the graduate level. It is unlikely to have much influence on PhD studies within the next five years. One of the new positions is expected to be in this area. The subcommittee was also told that the third appointment would be in soil mechanics. Most of these appointments will be at a junior level. It was suggested that their main justification lay in the undergraduate teaching load.

The subcommittee was interested to learn that a number of the PhD students at Carleton will be part-time students for the whole period of their doctoral studies. There is no residence requirement in the usual sense. It is possible for a student to do his research off campus, for example in a government laboratory. It is also possible that a student's main supervisor be someone who is not a member of the Carleton staff, although there will also be a Carleton professor acting as supervisor. The subcommittee was told that this procedure has been found successful. It may be noted that the largest PhD enrolment at any time has been ten and that the group has awarded only three doctoral degrees. The subcommittee feels that this kind of part-time programme has a number of obvious dangers as well as attractive features. As long as the enrolment remains small it may be possible to foresee and avoid the dangers, but we would urge the department to think very carefully about these regulations. It may, in fact, be that the city of Ottawa would be a useful place to introduce a DEng degree which would lend itself to part-time studies.

The subcommittee was impressed by the way the work in geotechnical engineering was presented as a joint undertaking of the two Ottawa universities. It was not, however, clear to us that full advantage was being taken by each university of the resources of the other in involving professors from both institutions on supervisory committees and qualifying examinations. Without such intimate collaboration Carleton would not be justified in offering the PhD in the geotechnical area and the Ottawa group would appear marginal. Together however, as has been said, there is a good group in geotechnical engineering.

We have indicated our belief that, while the structures programme contains some valuable elements, it has not been able to develop sufficiently to justify a doctoral offering. We have indicated that the structures activity at the University of Ottawa is, in our belief, at a satisfactory level. It certainly, however, would present a much more attractive training for a PhD student if the work in structures, like that in geotechnical engineering, could be a joint undertaking.

The subcommittee was interested to learn that the two universities in Ottawa had agreed that Carleton should develop the transportation field and Ottawa the field of hydraulics and water resources. This division of responsibility seems commendable but we believe both universities would also benefit by considering their PhD programmes in structural and geotechnical fields to be joint operations.

As has been noted, it appears important that there be advanced study and research in the field of transportation and we would therefore urge that Carleton emphasize this field in new appointments and in whatever other ways are possible. The subcommittee is, of course, unaware of undergraduate teaching requirements but insofar as graduate work is concerned we would counsel strengthening transportation for the next few years, if necessary at the expense of the other fields.

Recommendation 3

It is recommended that Carleton University

a) continue its doctoral programme in the field of transportation studies, making every effort to strengthen this group;

b) continue its collaborative doctoral programme with the University of Ottawa in the field of geotechnical engineering and, together with the University of Ottawa, formulate academic regulations that will tend to emphasize the responsibility of the whole group for the progress of each student;

c) initiate conversations with the University of Ottawa to develop arrangements for collaboration in the field of structures on the same basis as that described for geotechnical engineering.

It is recommended that the two universities report to COU by December, 1975, on the results to that time of the actions recommended in b) and c). It is recommended that if the report on b) is not satisfactory to COU, each university should then cease enrolling doctoral students in geotechnical engineering until such time as it has obtained a favourable appraisal for work in that field. It is recommended that if the report on c) is not satisfactory to COU, Carleton should cease to offer the PhD in the field of structures.

The last part of this recommendation does not suggest the alternative of an appraisal or of strengthening the Carleton group since there is quite adequate coverage of the field in strong PhD programmes in other Ontario universities.

5. UNIVERSITY OF OTTAWA

The discussion of different fields in Chapter 3 indicates that the civil engineering department in the University of Ottawa has satisfactory PhD offerings in water resources, in structures, and, together with Carleton, in geotechnical engineering. The department is able to grow in size. When the subcommittee met with the chairman a new appointment had just been made at the assistant professor level in the field of solid waste management (already counted in paragraph 3.6.3). The department is also interviewing for an appointment in the structures field, probably with specialization in engineering materials.

This last appointment will substantially strengthen the structures programme. As we have mentioned in our discussion of Carleton University, the structures programme would also be considerably more attractive if it involved Carleton faculty members in close cooperation.

We were interested to hear that there was considerable interaction between the members - both faculty and students - of the structures and geotechnical groups. Since this latter group is already essentially a joint operation, it may be relatively straightforward to extend this interuniversity cooperation into the structures field.

The strength of the work in geotechnical engineering depends rather sensitively not only on the collaboration of professors at Carleton but also on the part-time Ottawa professors whose principal appointments are in government departments. We were informed that a PhD student at Ottawa must be in full-time residence for a minimum of four semesters but that, in point of fact, most remained full time until they completed their theses. Those supervised by the part-time professors normally did their laboratory work in the University of Ottawa, except perhaps for the use of certain special equipment at the National Research Council.

The subcommittee had noticed the very long list of graduate courses in the Ottawa calendar. The chairman stated that the department was at present engaged in a severe pruning of this list.

The activity in the field of water resources would be expected to increase as the group of relatively young professors mature and consolidate their research. Increasing doctoral enrolment in this field at Ottawa appears to be consistent with the needs for engineers.

Recommendation 4

It is recommended that the University of Ottawa

a) continue its doctoral programme in the field of water resources;

b) continue its collaborative doctoral programme with Carleton University in the field of geotechnical engineering and together with Carleton University, formulate academic regulations that will tend to emphasize the responsibility of the whole group for the progress of each student;

c) engage in conversations with Carleton University to develop arrangements for collaboration in the field of structures on the same basis as that described for geotechnical engineering.

It is recommended that the two universities report to COU by December, 1975, on the results to that time of the actions recommended in b) and c). It is recommended that if the report on b) is not satisfactory to COU, each university should then cease enrolling doctoral students in geotechnical engineering until such time as it has obtained a favourable appraisal for work in that field.

6. McMASTER UNIVERSITY

The discussions of the different fields in Chapter 3 indicate that the civil engineering department at McMaster has an excellent offering in structures, the only field in which it offers doctoral work.

No additional appointments are at present authorized. The chairman indicated that if appointments became available the first priority would likely be in transportation where the teaching load is high and the master's degree popular. He said, however, that the department would also like to strengthen the water resources and the geotechnical fields.

As already noted, the work in structures emphasizes earthquake engineering but is not strictly confined to this specialty. The structures group is an important part of the provincial resources for PhD training and should be maintained at least at its present strength.

The subcommittee suggests that the department ought not concentrate all its resources in one field but should, in the long run, develop a second field for doctoral work. In view of provincial needs and McMaster's situation, the second field should be either water resources or transportation. For reasons to be given, the subcommittee favours transportation.

It seems clear that Waterloo and Queen's provide good opportunities for students who wish to specialize in the subfield that we have called hydraulics. There is, however, a need for some expansion of the opportunities in the environmental subfield. All three of Ottawa, Toronto and Waterloo have some established strength in this subfield and all three are on the verge of at least limited expansion. On the other hand, there is a real need to strengthen the province's offerings in transportation. The subcommittee feels that McMaster is in a favourable position to exploit either area.

There is a well established water quality programme in chemical engineering and the Canadian Centre for Inland Waters is situated in Burlington. In the field of transportation there are good relationships between civil engineering and the Department of Geography which has a strong offering in urban geography and Hamilton is in a part of Canada where transportation planning is a major issue.

Balancing these factors the subcommittee would suggest that McMaster's most useful role would be to keep its water programme centred in the Department of Chemical Engineering and to develop transportation engineering as resources become available. Since there seems to be a clear public need for engineers with an advanced specialized knowledge of transportation problems, it would be hoped that governments would make the resources available.

Recommendation 5

It is recommended that McMaster University continue its doctoral work in civil engineering in the field of structures according to its plans and, as resources become available, develop doctoral work in another field, preferably that of transportation.

7. QUEEN'S UNIVERSITY

The discussions of the different fields in Chapter 3 indicate that the civil engineering department at Queen's has an excellent offering in hydraulics, and a satisfactory offering in geotechnical engineering. It also offers the PhD degree in structures but this group is now weaker than it once was. Queen's does not offer the PhD in transportation.

The department does not expect to be able to make any net additions to the staff. On the contrary, it is not automatic that even retirements or resignations are replaced. The most recent appointment has been to the structures group. This group is described in paragraph 3.4.8. It may well develop considerable strength as its three younger members acquire experience, although at the moment it seems rather weak as a place for doctoral study. Nevertheless, because of the potential strength of the structures group and because the structures field is well developed elsewhere in Ontario, we would not advise Queen's to use any position that might become available to strengthen the structures group.

The hydraulics group is strong and is certainly capable of providing good PhD training to more students than are applying.

The geotechnical group looks promising but is quite small. From the point of view of graduate work, this is the area to which we would suggest adding a staff member.

Queen's is thinking in terms of an upper limit of 15 PhD students, graduating five or six per year. This seems within the capacity of the department but, in view of the enrolment prospects for the province discussed in paragraph 2.6, it appears a very optimistic figure.

In the light of the above facts, we are recommending that Queen's continue to offer the PhD in the same areas as at present. As far as structures goes, this recommendation is based on the potential of the group and we therefore suggest that in the fall of 1977 Queen's should begin an appraisal of the structures field.

Recommendation 6

> It is recommended that Queen's University continue its doctoral programme in civil engineering in the fields of hydraulics, geotechnical engineering, and structures according to its plans, strengthening the geotechnical group if possible and submitting the structures work for appraisal in the fall of 1977, ceasing to enrol new students in this field if the appraisal is not favourably completed by June, 1978.

8. UNIVERSITY OF TORONTO

The discussions of the different fields in Chapter 3 indicate that the civil engineering department at Toronto has satisfactory PhD offerings in structures, in geotechnical engineering, in environmental engineering and in transportation.

The department has a somewhat different age structure than the more recently established ones and expects three retirements during the next five years. Also at the present time, three new appointments are authorized, and recruitment is under way. Although a retirement at the University of Toronto is not necessarily replaced in the same department, the chairman feels that various considerations, including the very substantial undergraduate enrolment, will mean that there is a good likelihood that the department will obtain at least two, if not all three, of these positions. Most of these positions will be filled at the junior level but there is a prospect for a more senior appointment.

Clearly this department is in a rebuilding process and will have quite a different structure and appearance in a relatively short time.

The university is at present negotiating with candidates for a senior appointment in transportation. Every effort should also be made to add a junior staff member in this field if doctoral work is seriously to be pursued. It is suggested that Toronto might consider whether or not the current professional emphasis of the transportation group should be balanced by one or two people with a greater orientation towards research.

It was indicated that there will be a new appointment in the water resources field with a specialization in ground water pollution. There is some hope that a future appointment in this area might be a person with some expertise in air pollution - as has already been noted, the work of the water resources group is to a considerable extent interdepartmental. The subcommittee finds the plans commendable. The subcommittee also agrees with an intention to make a further appointment in soil mechanics, preferably of a person with a theoretical or analytical interest. It was also said that there would be a slow shift away from the structures field and that, in general, it would be hoped that new appointments might have interests that would span one or two fields of civil engineering so that the work of the department might become more integrated.

It should be mentioned that the department has master's students enrolled in surveying and did in the past confer at least one PhD in this field. We were informed, however, that the University of Toronto is developing work in cartography and surveying at Erindale College and that the present operation in the civil engineering department is thought of as transitional.

In the light of the above facts, we are recommending that Toronto continue to offer the PhD in the areas in which students are currently enrolled. In regard to transportation, this recommendation is based on the potential of the group, including the new senior appointment.

Recommendation 7

> It is recommended that the University of Toronto continue its doctoral programme in civil engineering in the fields of environmental engineering, geotechnical engineering, structures, and transportation according to its plans which involve new appointments to certain of these groups.

9. UNIVERSITY OF WATERLOO

The discussions of the different fields in Chapter 3 indicate that the civil engineering department at Waterloo has an outstanding PhD offering in structures, excellent offerings in water resources, and in transportation, and a rather weak offering in geotechnical engineering.

The department has 33 faculty members and would not expect any retirements in the next few years. It would not expect to grow, but some shift of emphasis in the fields is to be expected for two reasons. Perhaps most important, some of the faculty are making a conscious effort to change their research interests. In the second place, in a department of this size there are likely to be some resignations and, depending on circumstances, these might permit the strengthening of one of the groups.

As we have already indicated, the group in structures is clearly outstanding and should be maintained at this level of quality. It will not, however, be really weakened if some of its members develop some interest in other fields and this has begun to happen. In particular, some help has been given in this way to the water resources group.

The water resources group, to which an assistant professor was added in 1974, will receive another new appointment in 1975. The chairman feels that if the opportunity arose it would be desirable to make additional appointments in soil mechanics, water resources, and transportation, particularly perhaps in soil mechanics because of signs of increasing student interest and rather heavy teaching responsibilities.

Although geotechnical engineering can potentially benefit from the very strong structures group, it nevertheless is presented in the Waterloo calendar as a distinct doctoral field. The subcommittee is dubious that the group is, at present, strong enough to offer a PhD and we therefore feel that an appraisal is indicated. In view of the apparent intention of the department to strengthen the field, we suggest that the appraisal should not be immediate.

Recommendation 8

> It is recommended that the University of Waterloo continue its doctoral programme in civil engineering, in the fields of structures, water resources, transportation and geotechnical engineering according to its plans, but that it submit the work in geotechnical engineering for appraisal in the fall of 1977, ceasing to enrol new students in that field if the appraisal is not favourably completed by June,1978.

ADDENDUM TO REPORT OF
ACAP SUBCOMMITTEE ON CIVIL ENGINEERING
April, 1975

The subcommittee makes the following observations on certain points in the comments from universities.

1. Quality Ratings

All quality ratings contain a subjective element. Having said that, the subcommittee wishes to record that it believes it gave conscientious attention to weighing all the factors listed in its report, including professional activity.

The subcommittee reiterates that the ratings refer to the suitability for doctoral study, the only thing they attempted to evaluate. A department without a doctoral programme, or with a relatively weak one, may still be a good place for undergraduates and may contain some professors with laudable professional or research activities.

The subcommittee regrets its attempt to define the four quality ratings (outstanding, excellent, satisfactory, questionable) by parenthetic phrases in pp. 1-12 of its report. In particular, the phrase for "excellent" (e.g., one of the best four or five in Canada with some international recognition) has been misunderstood. Of course, if there are only four or five programmes in Canada in a field, it does not follow that all are excellent; indeed, if there are seven or eight, one might not expect as many as four or five to be "excellent". The phrase would be a more appropriate description for a basic arts or science discipline.

The subcommittee would also stress that the category "satisfactory" is broad and, of course, includes some good, promising, substantial programmes as well as some more marginal ones.

After the circulation of the subcommittee report, two universities supplied extensive amounts of further information which might well have been provided earlier, particularly since the subcommittee's modus operandi was known when the original submissions were requested in September, 1974. This did cause the subcommittee to have a fuller picture of some situations than it had had, and might have altered some relative ratings had the subcommittee been making relative ratings within categories (it did not do so).

The subcommittee report has also been altered to include certain corrections to the data previously provided by the universities. Numbers in the paragraphs relating to Toronto have not been altered, since the new material was not submitted in a form which would make it possible to know if any data previously provided were inaccurate. However, the detailed response from the University of Toronto is appended and contains some numerical data, which, while not strictly comparable with that in the subcommittee report, is generally similar. (See Appendix 2, pp. 2-23).

2. Terminology

The response from Queen's draws attention to the subcommittee's use of the term "water resources" to exclude "hydraulics". This is inconsistent with general usage and with the consultants' report. The subcommittee has therefore amended its report in this respect. The term "water resources" in the version presented to COU encompasses two subfields: "hydraulics" and "environmental" (see pp. 1-17).

3. Specific Points

a. Hydraulics at Toronto

Hydraulics, or more generally hydrotechnical work as opposed to environmental water engineering, is a field at Toronto in the Department of Mechanical Engineering. Certain professors in the Department of Civil Engineering are involved in this programme, but the civil engineering department does not have any doctoral students enrolled in this subfield of water resources. This work, then, was covered in the report on mechanical engineering.

b. Transportation at Queen's

Queen's asks why it is not encouraged to develop civil engineering PhD work in transportation. The simple answer is that it indicated no plans to do so In the sense that more emphasis should be given to transportation, it might be a reasonable proposition that Queen's gather the resources for such an undertaking. But the subcommittee does not so recommend for two reasons. In the first place, it is our understanding that Queen's has little opportunity to add or change teaching staff and we believe that the present fields should be maintained and, if possible, improved. In the second place, further development in transportation can take place in the three currently established programmes--the suggestion with regard to McMaster was made because the subcommittee felt McMaster's offering, now confined to one field, should be broadened. This consideration does not apply to Queen's.

APPENDIX 2

University Comments 2-1 to 2-57
Discipline Group Comments 2-58

CARLETON UNIVERSITY

RESPONSE TO THE REPORT ON PH.D. PLANNING ASSESSMENT

BY THE

ACAP SUBCOMMITTEE ON CIVIL ENGINEERING

We wish to comment only very briefly on this report and shall omit the inclusion of a large number of smaller points which have come to our attention.

In general, we question seriously the procedure and process which led to this report: the attempt to judge the adequacy of the environment in which doctoral students are being prepared, including the quality of faculty, on the basis of the previous consultants' report (which was deemed to be inadequate), some additional documentation, and discussions with chairmen only (and without civil engineering specialists on the subcommittee). It is not surprising, therefore, that many of the arguments which were adduced in declaring the previous report inadequate could also be applied to this latest report.

In the circumstances, we would suggest that the matter of further appraisals and assessment be allowed to wait for a period of a year or two while individual institutions explore the possibilities of development in some of the directions being recommended in the reports and that following this interval a careful re-assessment should pay close attention to related fields such as architecture.

On one specific recommendation affecting Carleton, we do wish to press strongly for an amendment. Carleton and Ottawa Universities are asked to explore and develop further collaboration in the fields of geotechnical engineering and structural engineering and report satisfactory results to COU by December, 1975 on pain of having to cease enrolling doctoral students. We find this period to be impossibly short in view of the sensitivity and complexity of the negotiations required and the legitimate absence of senior key personnel on previously arranged leaves. The deadlines set for other institutions seem far more reasonable and we would request that our deadline be revised to December, 1976.

G. R. Love
March 19, 1975

McMASTER UNIVERSITY
Dean of Graduate Studies
1280 Main Street West, Hamilton, Ontario, L8S 4K1
Telephone: 525-9140

March 26, 1975

Dr. M. A. Preston,
Executive Vice-Chairman,
Council of Ontario Universities,
130 St. George Street,
Suite 8039,
Toronto, Ontario. M5S 1M8

Dear Dr. Preston:

I am pleased to submit to you our comments on the ACAP Civil Engineering subcommittee report.

Although McMaster is generally pleased that its current doctoral work in Civil Engineering is recognized as being of excellent quality, we disagree with some of the divisions of the field that are used in the report as the basis for the recommendations. In general, we submit that the report makes more detailed comments and recommendations than would appear to be warranted considering the nature of the data available and the particular methods used in assessing these data. The comments which follow are addressed to the particular fields of specialization used in the report and the comments are based both on the report and the revised McMaster plan which was submitted in October,1974 in response to your request dated September 30th, 1974.

Structures

The subcommittee's report distinguishes between geotechnical activities and structures. This is not a distinction that we accept and in our revised plan which we submitted in October, 1974 we grouped the two activities together. We believe that they cannot be separated meaningfully, especially in regard to earthquake engineering, and it was our understanding that there had been some earlier agreements that the assessment would be conducted in three broad fields with the geotechnical activities included within the field of structures. We are very disappointed to see that the subcommittee has not followed this course of action. Rather, the subcommittee has interpreted the data given in our October,1974 report in particular ways and the statistics in Table 3.1 reflect these interpretations. The doctoral enrolments which we reported have been interpreted as being all in the structures area but whereas we reported that we had nine faculty members working in structures, the report acknowledges only seven. The particular reference to one of our Assistant Professors devoting some of his time to geotechnical engineering is incorrect; this faculty member devotes practically all of his time to geotechnical engineering, even though a part of this is closely linked to the structural activities in earthquake engineering. We would point out further, by way of example, that one of our Ph.D. students studying the dynamic interaction of a pile and its surrounding soil during earthquake excitation has successfully defended his doctoral thesis within the past few weeks. In addition, several other doctoral students are currently doing research on soil-structure interaction problems.

In the light of the above comments, we would prefer to interpret the remarks in Sections 3.4.2, 3.4.9 and 6 in the report as including geotechnical activities within the structures field and we would wish to see this acknowledged explicitly in the recommendations concerning McMaster.

Hydraulics and Water Resources

We do not agree that the distinction which is made between hydraulics and water resources in Section 3.6 is a very useful one for planning purposes. In the case of McMaster, the apparent reason for making the distinction is that the work in waste water had in the past been done within the Department of Chemical Engineering. The McMaster plan however, includes both areas together and we feel that the assessment for doctoral planning must recognize this fact. Five faculty members, two of whom are Associate members from Chemical Engineering, are active participants in research and graduate student supervision within Civil Engineering. Four of these five are Civil Engineers and all are also involved in teaching undergraduate Civil Engineering courses. We would point out that in our submission dated October, 1974, we made explicit reference to the fact that Dr. Murphy holds a joint appointment in the Departments of Civil Engineering and Chemical Engineering. The information given in Table 3.1 of the report suggests that he has been disregarded completely in assessment.

Further evidence of the actual development of this field as an interdisciplinary activity at this University is the existence of a working arrangement between the Chemical and Civil Engineering Departments for graduate students in water resources, both at the Master's and Ph.D. levels, to register in the Department of their undergraduate degree. The existence of the Canada Centre for Inland Waters was mentioned in the subcommittee report; we would like to emphasize that liaison with C.C.I.W. has increased significantly within the past year. Relative to environmental activities, there are also several other faculty members in Geology and in Biology who are active in the water resources field and who have a working liaison with the water resources group in engineering. The large number of M.Eng. students currently enrolled provides an excellent source of quality doctoral students; it should be noted the number of full-time Master's students at McMaster in this field is larger than at any other Ontario university. In addition, the need for the application of research to practical water resource problems in the Hamilton region and surrounding area (e.g. Hamilton Harbour, Lake Ontario, Welland Canal, Coote's Paradise, Spencer Creek Watershed) provides an excellent environment for the education of professionals in this field.

In other words, we submit that we already have a strong commitment to doctoral work in hydraulics and water resources and that the further strengthening of cooperative arrangements between the Departments of Civil Engineering and Chemical Engineering will encourage the development of this area of doctoral work.

Dr. M. A. Preston — March 26, 1975

Our assessment of our relative potential and strengths in water research compared to Transportation prompts us to question the wisdom of the subcommittee recommendation that we emphasize the latter at the expense of the former. We are appreciative of the report's recognition of the potential and desirability for development of doctoral work in transportation at McMaster and we intend to continually review this possibility over the next year or so. At present, the University is unable to commit additional resources to the field of Transportation although we recognize that the Department and the Faculty of Engineering rates this a high priority area.

Very sincerely yours,

Leslie J. King
Dean

LJK/del

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CABINET DU RECTEUR

OFFICE OF THE RECTOR

March 20, 1975

Dr. M.A. Preston,
Executive Vice-Chairman,
Advisory Committee on Academic Planning,
Ontario Council on Graduate Studies,
Council of Ontario Universities,
130 St. George Street, Suite 8039,
TORONTO, Ontario. M5S 2T4

Dear Dr. Preston,

This is a reply to your request for the University's comments on the ACAP report on Civil Engineering which, I am pleased to say, we find generally acceptable. I should like to make some comments on several points in the report.

Our department generally favors recommendation 1 (p.1-4) and is presently investigating the local demand and the financial implications of offering a practically oriented part-time research programme leading to the Doctor of Engineering degree.

As in the case of the University of Waterloo, our already large enrolment in the field of Hydraulics and Water Resources has obliged us also to limit our student admissions to the graduate programme in this area (see p.1-18).

With regard to the large number of graduate courses listed in our calendar (1-24), I can report that the Civil Engineering Department is presently reviewing its course offerings and will shortly be reducing the number of courses to be offered. Unfortunately, next year's calendar has already gone to print but the change will be evident in subsequent editions.

With regard to recommendation 4(c) on 1-25, although it may not have been emphasized in our original submission to ACAP, co-operation between the structures groups of both universities has been going on for years. However, we propose shortly to prepare a formal document setting out the extent of co-operation in the Geotechnical and Structures areas. We shall send a copy to the ACAP office when it is prepared.

I should add that in the field of water resources we have five full-time professors as indicated on p. 1-18 of the report. The table on p. 1-11 only indicates four. Applicants are still being interviewed for the vacant position in the field of structures. When the position is filled the staff in that area will consist of one professor, two associate professors and one assistant professor. The establishment of the department now stands at twelve.

Yours sincerely,

Roger Guindon, O.M.I.,
Rector.

c.c. P. Hagen
A. D'Iorio

March, 1975

COMMENTS BY QUEEN'S UNIVERSITY ON A.C.A.P. CIVIL ASSESSMENT

In the memorandum of transmission of the A.C.A.P. report on Civil Engineering (February 4th, 1975, M.A. Preston to Deans of Graduate Studies etc), the intent is to treat the report as a consultant's report which may be commented upon for factual errors and for omissions arising from inadequate or misunderstood departmental presentations, written or oral. Queen's University feels that the following comments are in this spirit and will result in significant improvements in the final report of A.C.A.P. to C.O.U.

In what follows each field is treated separately on the basis of factual errors and omissions, with comments appropriate to the field arising from these omissions. General comments on the field follow these in each instance.

As a result of the enclosed comments, Queen's Civil Department requests a meeting with the A.C.A.P. Sub-committee in an effort to be helpful to A.C.A.P. in generating a more meaningful final report to C.O.U. (as suggested in the memorandum of transmission mentioned above) and to clarify, if need be, comments made in this submission.

1. COMMENTS REGARDING THE DEFINITION OF FIELDS

The central thrust of the A.C.A.P. report on Civil Engineering deals with the "role of each department in respect to the different fields of doctoral research", and to a considerable extent the evaluations given in the report depend on the allocation of a department's research endeavour into one or another research field. Despite this, the report has scarely touched on the question of defining research fields, and the delineation that is contained in the A.C.A.P. report appears to be somewhat capricious.

For example, the field of 'structures' is nowhere defined in the report, but by implication it has been taken to include the fluid mechanics of wind tunnel modelling.

The view expressed on page 1-15 that "geotechnical engineering...is often considered a part of the structural field..." is an eccentric one which is at variance with the practice of major engineering schools in the UK and the USA. Indeed, as is well known in the civil engineering fraternity, papers reporting research on geotechnical engineering and structures are seldom published in the same technical journals. This is true on the international scene and also within Canada, as can be seen by the Canadian Geotechnical Journal.

Likewise, the A.C.A.P. report has adopted an idiosyncratic definition of 'water resources' (page 1-17) which is grossly at variance with the normal technical usage. The term water resources is commonly used to describe a very wide field which includes contributions from civil engineering, economics, politics, law, biology, chemistry, forestry, planning, geography, geology, systems engineering etc. A cursory inspection of the journal, "Water Resources Research", will confirm this observation. The contribution of civil engineers to water resources has largely been through two fields viz (1) hydraulic engineering and engineering hydrology or, as the Canadian Society for Civil Engineering has chosen to term this field, hydrotechnical engineering, and (2) that part of the field traditionally known as sanitary engineering (now termed environmental engineering) which deals with water quality. It should be emphasized that these are two distinct fields and although there are common aspects, not all hydrotechnical engineers are concerned with water quality and perhaps more significantly, not all environmental engineers are concerned with water.

The incorrect application of the term "water resources" exclusively to a portion of environmental engineering is a misleading factor of the A.C.A.P. report. Some improvement could be obtained by reverting to the classification suggested in the original consultants report, i.e. using the term 'water resources engineering' to denote the combined field described in the A.C.A.P. report as 'hydraulics and water resources'. However, such a classification would still omit that significant portion of environmental engineering which is not concerned with water, (e.g., air pollution, solid waste disposal, etc).

The fact that two separate fields of research (which may best be called hydrotechnical engineering and environmental engineering) are lumped together in the A.C.A.P. report creates some confusion. If these fields are to be taken together, then the A.C.A.P. imprimatur must be applied to the uneasy combination as a whole. On the other hand, if in effect the two "sub fields" have been evaluated separately in the A.C.A.P. report, then a clean split should be made. Obviously if the latter course, which is more in accord with present reality, is adopted, then following the same 'marking scheme', it would be necessary to drastically revise the quality assessment as given in the report.

2. COMMENTS WITH REGARD TO HYDROTECHNICAL ENGINEERING AT QUEEN'S UNIVERSITY

a. Item 3.6.1 Page 1-18

This section of the report is inaccurate. A corrected version is given below with changes in italics.

> "3.6.1 Queen's University
>
> In doctoral training the emphasis at Queen's lies entirely in hydraulics. The group consists of *five full time and two part-time* faculty members engaged in research and graduate study, five of them professors and two associate professors. Publication is satisfactory, consisting of *2 books*, 8 refereed articles and 12 conference contributions in the last two years. The average NRC operating grant is $7,200. At present there is one doctoral student but there were 7 in 1971-72. There are also 10 master's students in the group. Since 1962 there have been 14 Ph.D.s awarded.
>
> The principal specialt*ies are* coastal engineering, *sediment transport and hydrology*. The group has an international reputation. *Further areas of research include ice mechanics and waste treatment processes."*

In addition, this section of the report suffers from a lack of any mention of professional competence and experience (see for example Item 3.4.3 on page 1-14, lines 15, 16 and 17). A proposed paragraph on this topic follows below.

"The group is actively involved in professional consultation, such as the design of hydraulics laboratories including the Canada Centre for Inland Waters, coastal and harbour designs in Canada and abroad, model studies of spillways and ship channels, advising the native peoples concerning the impact of the James Bay hydroelectric project, and the design of vortex clarifiers."

3. COMMENTS WITH REGARD TO GEOTECHNICAL AT QUEEN'S UNIVERSITY

a. Item 3.5.3 Page 1-16

This section of the report has deficiencies of information. A corrected version is given below with changes in italics.

> "3.5.3 Queen's University
>
> The Geotechnical group contains three faculty members - one in each of the professional ranks. All three are active in research and supervise graduate students and each has a good publication record. *Since 1958 one quarter of the group's research funding has been from NRC and* the present average NRC grant is $9,900, but of course the assistant professor is still at the NRC "starting" grant. There are three Ph.D. students and 13 master's students *and one research associate (attachment 1). Five* Ph.D.'s have been awarded since 1970.
>
> There is a close relationship with the Geology Department, Geology professors being on most supervisory committees.
>
> *There are also close relationships involving doctoral students with the Mining Department in the field of Rock Mechanics, the Geography Department in the fields of Geomorphology and Pedology, and with Mechanical Engineering in the fields of Elasticity and Dynamics. (These three departments have been recognized by A.C.A.P. as being competent at the Ph.D. level in the fields related to Geotechnical.) There is also liaison with two R.M.C. geotechnical staff.*
>
> The research fields lie in soil mechanics and are more particularly described as stress-strain behaviour, theories of consolidation and field permeability related to actual construction cases, influence of repeated loadings, influence of frost heaving, *permafrost* and performance of railroad track ballasts and fills.
>
> *The above research fields in addition to the NRC funding mentioned previously are substantially supported by D.R.B. and C.I.G.G.T. grants in the amount of $85,000 per annum in the 1974/75 year."*

b. Comments Arising from Factual Revisions Above

On page 1-11 the current enrolment of Ph.D.'s and M.Sc.'s is as follows:

Western	4 M.Sc.	2 Ph.D.'s (+ 1 P.T.)
Queen's	9 M.Sc. (+ 4 P.T.)	3 Ph.D.'s

It is the policy of the Geotechnical group to obtain NRC funding for topics where it is difficult to obtain industrial support. It is believed that if industry is capable and willing to fund research it is irresponsible for the group to throw the total funding of doctoral research on the inadequate shoulders of NRC.

In view of the greater funding for research, the wider variety of course offerings and expert staff available in related fields of study, the substantially larger graduate enrolment and the international reputation of the senior Queen's staff the rating of satisfactory in relation to that of Western must be queried.

4. COMMENTS WITH REGARD TO TRANSPORTATION AT QUEEN'S UNIVERSITY

a. Item 3.7.5 page 1-20

This section is slightly inaccurate. A corrected version is given below with changes in italics.

> "3.7.5 Queen's University
>
> Queen's *has not in the past offered* the Ph.D. in Transportation but has an enrolment of five master's students. *The master's programme is the oldest in Canada having graduated over 20 M.Sc. students since 1958.*
>
> The work is the responsibility of *effectively two faculty members."*

b. General Comments

The A.C.A.P. Report identifies transportation as one of the areas where there will be a demand for increased engineering expertise (para 2.3). A.C.A.P. also feels that the total need for Ph.D.'s may have been underestimated, particularly in transportation and water resources (para 2.6). We do not think that any one would disagree with increased engineering expertise, but we do not see that the need for Ph.D.'s automatically follows.

In our opinion transportation is a practical rather than an academic problem. The problem with the education of transportation engineers is a paucity of suitable courses at the undergraduate level. Education in Transportation Engineering must be obtained by the student at the graduate level. A brief survey of some engineering consultants and provincial government personnel indicates that they put great emphasis on the courses but little on the research undertaken by the student. Also they show little enthusiasm at present for students with Ph.D. degrees. They feel a master's is satisfactory.

In spite of this point of view it is obvious that the A.C.A.P. report encourages the development of strong transportation groups in Civil Engineering departments, and it seems logical that Queen's with its long past history in this field at the Master's level be encouraged to offer a Ph.D. programme in Transportation.

Every other university that has minimal expertise on its staff to teach transportation is encouraged to expand and get into the business, (e.g., Recommendation 5), but Queen's is dismissed in one sentence.

One of two things must have happened, either A.C.A.P. has decided that Queen's is not a suitable place to strengthen and extend its transportation programme or A.C.A.P. had the impression that Queen's cannot and will not give a Ph.D. in transportation.

In our opinion, in comparison to other universities in Ontario as outlined in the A.C.A.P. report Queen's has greatly more potential to establish a Ph.D. programme.

(1) We have a well established Master's Programme, the oldest in Canada - graduating students since 1958. These graduates are now working in key posts with governments and consultants and have helped modify our programme in the light of their experience.

(2) Our library holdings are extensive.

(3) Transportation is not a subject that is wholly the prerogative of the engineer. Thus the education of a good transportation planner required a breadth of knowledge of the subject. In recognition of this the transportation group at Queen's has established excellent working relationships with

(a) School of Urban and Regional Planning

(b) School of Business - where Professor H.V. Fullerton (formerly a consultant and director of the Metro Toronto Area Regional Transportation Study) has courses on Operations research and transportation systems.

(c) Department of Geography

(d) Department of Economics

(e) Faculty of Law

(f) Institute of Local Government

(g) Department of Political Science

(h) Canadian Institute for Guided Ground Transport

The latter institute provides an unique opportunity for students to become involved in large scale studies. Our students have been associated with an Arctic Railway Study and a Study of the MacKenzie Valley Transportation Corridor.

(4) Our current research is developing into the area of transportation systems problems which may provide the more academic research topics that may be suitable for Ph.D. work..

(5) There is an implication in the report that transportation research can only be undertaken in universities located in large cities where there are urban transportation problems - hence McMaster should develop a Ph.D. programme (Recommendation 5). This is not so. Urban problems are only one aspect of transportation difficulties. The data for transportation research is portable in the same way that moon rocks are portable. One does not have to be on the moon to study moon rocks, in fact it may be the worst possible place. At Queen's we have traditionally aimed our research at the smaller municipalities and rural areas. We feel these problems need particular study in Canada, today.

5. COMMENTS WITH REGARD TO STRUCTURES AT QUEEN'S UNIVERSITY

a. Item 3.4.8 page 1-15

This section of the report is inconsistent with other structures items and consequently inaccurate. A corrected version is given below with changes in italics.

"3.4.8. Queen's University

The structures group at Queen's now consists of 5 faculty members - one professor, two associate professors and two assistant professors. One of the assistant professors is newly appointed, having just completed his own doctorate. The publication activity of the group *consists of 9 refereed articles in the past two years* and the average NRC operating grant for the three members who have grants is $5,800. On the other hand *two* members of the group are very active in contract activity for the Ministry of Transportation and Communications, doing research and design on highway bridges, *which have been funded at a rate of $50,000 per annum for the latter two years.* The other current field of research is polymer concrete.

Queen's has graduated 13 people with Ph.D.'s *since 1962* in structures. *The present staff has supervised 6 Ph.D.'s in the past five years.* The current doctoral enrolment is 3 and there are 8 master's candidates.

The group has recognized expertise in the field of modelling concrete structures and in polymer concrete properties."

b. Comments Arising from Factual Revisions Above

The number of Ph.D. students graduated is as follows:

McMaster	6 in 5 years
Western	5 in 4 years
Queen's	6 in 5 years

In view of the above output of Ph.D.'s, the substantial research funding from other than NRC sources, and the expertise in fields not covered elsewhere, the questionable rating of Queen's in relationship to that of Western and McMaster is totally incomprehensible in 3.4.5.

c. Additional Comments on 3.4.9. Quality Summary

(1) Recommendation 1 (page 1-4) states, in part, that civil engineering departments should consider establishing programmes suitable as preparation for work in an industrial environment. It is our belief that the Queen's doctoral programme in structures, as substantiated by its production and industrial research funding, has in the past emphasized research problems of immediate relevance to the civil engineering industry, and continues to do so.

(2) The sub-committee has expressed the opinion that the quality of education is influenced by the available faculty. It is also stated that judgments in the report were based on the number of faculty and the extent to which they met the criteria described for thesis supervisors. These criteria are outlined on page 1-12. Accepting these criteria we do not feel that the descriptions of each group (see Sections 3.4.1 to 3.4.8) give evidence that these standards were uniformly applied to all groups. For example, in some descriptions the nature and amount of contract funding are glossed over, while in others they are emphasized. Some summaries refer only to publications in refereed journals, others list the total number of research items. For example Queen's has, we believe, more than adequately satisfied the criteria listed on page 1-12, as having professional experience and displaying research activity as evidenced by theses directed, contracts fulfilled,etc but reference is made only to the low publication record and low NRC grants. We feel that the research relevance of the activity in contract research in which Ph.D. students are involved for thesis purposes was not appreciated by the sub-committee even though it speaks of the importance of contract funding for research of practical interest.

(3) It is true that doctoral enrolment at Queen's has been dropping during the last six years. However, the enrolment in the structures specialization at Queen's has been maintained at a level close to the mean for the past six years. It may be pointed out that six of the sixteen Ph.D.'s granted in civil engineering at Queen's since 1971 have been in the structures field. All are successfully employed in government design agencies or consulting firms. Further, there has been no indication that employers are dissatisfied with Queen's preparation of its doctoral candidates in the structures field or that their preparation has been questionable.

(4) We do not propose at this time, to argue against the criteria adopted by the sub-committee for assessing supervisors of doctoral students. It is not clear however what weights are assigned to these desirable qualities. There are inconsistencies in the description of groups from university to university with different criteria being stressed in each case. Some of these have been referred to previously in our discussion of section 2.5. Specifically Western's NRC grant performance is not listed, but contract research at that institution is given prominence. The Queen's group description reverses this emphasis. Another inconsistency arises from the reporting of the number of students completing degrees. This number is stated in section 3.2 to be a criterion for judgment. However, in the group description this is explicitly referred to in some cases and not in others.

The discipline group has rightly indicated that publication in conference proceedings have a variable significance as an indicator of research activity. In instances where the department chairman is conversant with the structures field the research significance of a particular conference would probably be correctly assessed, but where the chairman's specialization lies in another research area the value of the conference publications may be underestimated. The refereeing system for an American Concrete Institute Conference, for example, is comparable to that for a journal, yet faculty publishing in these conference proceedings would not receive credit in the eyes of the sub-committee without a favourable intervention from the chairman of their department.

(5) It is difficult to accept the statement on the bottom of page 1-12 that the evaluations apply solely to the suitability for the training of Ph.D. students. There is no doubt that the evaluation will by implication extend to the M.Sc. program. The sub-committee also appears to be of this opinion in spite of the disclaimer on page 1-12, since on page 1-5 the sub-committee states that "in order to be effective in teaching a faculty member must be involved in research or advanced professional practice".

(6) We feel that the sub-committee has applied different criteria for the evaluation of the different groups and that the Queen's structural group has been judged questionable mainly on the basis of comparison with the inordinate strength in the so-called "structures" groups at some other universities. The structures group at Queen's is stronger than some groups judged 'satisfactory' in the transportation and water resources areas. It would seem that the question to which the sub-committee should address itself is the evaluation of the competence of a particular group to supervise doctoral students per se.

(7) In section 2.5 the sub-committee states that they have taken account of the extent of specialized activity throughout the Province. It is proper to consider this when making general recommendations such as recommendation 2 concerning the Transportation area. However, it does not seem reasonable to judge a group questionable on this basis since a questionable evaluation means that the quality has been found to be "inadequate or further study is required to establish its adequacy".

d. Comments on Section 3.4 Structures

The following observations apply to the descriptions of other groups offering doctoral programs in structures.

(1) 3.4.2 McMaster University

McMaster has graduated 6 Ph.D.'s in the last five years - precisely the number that Queen's has graduated.

(2) 3.4.3 University of Western Ontario

In the last four years Western has graduated 5 Ph.D.'s about the same number as Queen's. Research involvement in projects such as the CN Tower and the Bank of Montreal are listed, but the research involvement of the group at Queen's with the Ministry of Transportation and Communications has not been given similar emphasis.

(3) 3.4.4 University of Ottawa

This summary omits reference to the group's past performance - how many Ph.D.'s has the group graduated?

(4) 3.4.5 University of Toronto

The group at the University of Toronto, comprising 12 faculty members, has produced 5 or 6 research articles in refereed journals. This publication record is said to be adequate. The group at Queen's comprising 5 faculty members, has produced 9 refereed articles, however this record is said to be low. Again the summary omits reference to the group's past performance - how many Ph.D.'s have been awarded?

e. Comments on 3.4.8 Queen's University

We feel that the A.C.A.P. report has placed emphasis on the negative aspects of the group's past performance while de-emphasizing the strength of the group. The average NRC grant is $5,800, however the total research funding is considerable, amounting to $160,000 over the past two years. The major portion of this funding was provided for research on new bridge systems in prestressed concrete. The research was undertaken at the request of MTC, which acknowledges the group's expertise in the modelling of concrete structures (attachment 2). Several Ph.D.'s and M.Sc.'s have resulted from projects completed for the Ministry. One member of the group has gained international recognition from the Prestressed Concrete Institute for his work in bridge design (attachment 3), while another has recently been invited to be a panel speaker on prestressed concrete bridge research in Ontario at the CSCE Second Structural Concrete Conference to be held in Toronto in October 1975. International recognition has also been achieved by another member of the group for his work on polymer concrete, which forms part of the research activity on concrete materials. He is currently in receipt of invitations to deliver lectures at four foreign universities during 1975. In addition the newly appointed assistant professor in the group has been invited to collaborate with an internationally known researcher in the U.S. on an analytical project totalling more than $250,000 over a two year period. It has been pointed out that a research associate (post-doctoral), with a background in structures, is employed within the Department in the Geotechnical group. In addition a full-time research assistant has been employed on contract research for the past two years.

f. Comments on Queen's University (Page 1-28)

The sub-committee states that the structures group at Queen's is weaker than it once was. There is no basis for this conclusion. There are presently more staff members actively engaged in supervising graduate students and research than at any time.

ONTARIO

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

MINISTER: HONOURABLE CHARLES MacNAUGHTON
DEPUTY MINISTER: A. T. C. McNAB

Engineering Research Branch,
Downsview 464, Ontario.
February 2, 1972.

Dr. B. deV. Batchelor,
Dept. of Civil Engineering,
Queen's University,
Kingston, Ontario.

re: OJHRP Project Q47

Dear Barry:

The report on Project Q47 is now being prepared for publication and our technical editor has asked me to supply, if possible, the errata information and original copies of the figures for the report. Apparently the photographs contained in your draft copies of the report are already screened and a further screening will be required to reproduce them; this results in rather poor printed reproductions.

Regarding the errata information, I know that you have sent this to me, but at the moment I seem to have temporarily mislaid it. Your early attention to this matter will be greatly appreciated since it will expedite publication of the report which is scheduled for this month.

Enclosed are sketches showing the new precast post-tensioned concrete I-beam designated Ontario-90. The Bridge Office is concerned about the discontinuities due to the presence of cable ducts in the relatively thin web section. They would like to know whether the duct and grout become an integral part of the cross-section and what is the danger and its effect on design if not. I thought the answers to this query can be obtained through micro-concrete modelling of which your Department has accumulated considerable expertise in the past few years.

The other problem is also associated with precast concrete; in this case - a trapezoidal three-sided box section. The enclosed drawings and description are self-explanatory. As far as structural height is concerned, the new regulations specify clear span length divided by 28.

The usage of precast concrete in bridge design is coming back to vogue as it should, and I feel some efforts should be devoted to make sure that no problems will result from the application of thin concrete elements. As far as the approval of future projects is concerned, they will be subject to the same financial and administrative conditions as before.

Yours truly,

P. Csagoly

P. Csagoly,
Head, Structural Research.

PC/mg
Encl.

c.c. Mr. C. Bassi.

2-19

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AN AWARD WINNER

IN THE 1974 P.C.I. AWARDS PROGRAM

GRATEFULLY ACKNOWLEDGED

NOVEMBER 26, 1974. *PRESIDENT, C.P.C.I.*

UNIVERSITY OF TORONTO
School of Graduate Studies

OFFICE OF THE DEAN
Toronto 181, Canada

March 19, 1975

Dr. M.A. Preston,
Council of Ontario Universities,
Suite 8039,
130 St. George Street,
Toronto Ontario

Dear Dr. Preston:

The report of the ACAP subcommittee concerned with doctoral work in civil engineering does not seem to the University of Toronto to provide a proper base for planning for the discipline. This University has always held the view that assessment of the quality of programs at individual institutions must be central to the assessment process. For that reason, we supported ACAP's view that the original consultants' report was inadequate. However, quality assessments, to be useful, must be seen to be soundly based in fact, and to reflect the considered judgement of leaders in the field concerned. While we recognize the problems faced by the subcommittee, and can only applaud its conscientious efforts to deal with an already difficult situation, we regret that we are unable to regard its assessments in that light.

Part of the difficulty seems to stem from factual errors. We must accept our share of blame for these: however, it must be noted that our original submission was drafted in the expectation that it would be examined by experts in the discipline.

As an example of errors in fact, we may note the comment 'The group's support is mainly from NRC...' (p. 1 - 14) relating to our structures group, which has consistently, over 1972-75, received about two-thirds of its support from sources other than NRC. In order that the subcommittee may have an opportunity to correct such errors, we append to this letter the response of the Department, which gives considerably more detail than was perhaps available to the subcommittee.

The real difficulty appears to be more fundamental than this. We do not deny that, in principle, the subcommittee's experience should permit it to make at least broad quality assessments. (We would, however, question whether persons outside the discipline can properly judge international stature, and, indeed, section 2.4 of the report seems to indicate that the Discipline Group may have effectively made this judgement.) We also realize the great pressure placed on the subcommittee by the COU deadline. However, we question whether written documentation, supplemented only by meetings with the Discipline Group and individual chairmen, forms an adequate information base for recommendations involving appraisal and even discontinuance of programs. Certainly it is our view that it would be very difficult, if not impossible, for the subcommittee to assess correctly the interdisciplinary strengths of this University, particularly in transportation, without visiting the departments concerned.

In assessing any doctoral program, we believe the following factors must be considered:

a) the quality of the staff of the department, particularly with regard to supervision;

b) the totality of resources in the University available to mount the program, and, in particular, the breadth and depth of course work offered;

c) the standards met by the program, as demonstrated by admission standards and standards for the Ph.D. thesis.

We recognize that the subcommittee made a serious attempt to assess staff quality. While we are in some disagreement with the subcommittee as to the weight to be given to publications other than those in research journals (section 3.2), we are prepared to accept the judgements arrived at as generally sound. We see little evidence, however, in the subcommittee's quality assessments that either of the other factors was given significant weight.

To sum up, we have not sufficient confidence in the way in which the quality assessments were derived, or in the criteria applied, to be able to support the recommendations as a sound basis for planning.

To turn now to the recommendations themselves, we have the following comments.

Recommendation 1

This University has considered on more than one occasion in the past the establishment of a Doctor of Engineering program. Our conclusion has been that such a program is unnecessary. Our current Ph.D. program has been demonstrably successful in preparing students for careers in industry, and we have encountered no difficulty in including adequate professional content in Ph.D. programs.

Recommendation 2

We do not favour any attempt to define subfields, (within the four defined fields). Such definitions, we believe, serve no useful purpose. An example of what we consider to be over-definition of subfields occurs on p. 1 - 16 (section 3.5.2), where permafrost engineering is defined as not falling within soil and rock mechanics. Would sand and gravel mechanics also constitute a new field?

Recommendation 5

With three satisfactory transportation programs in the province, with only 8 full-time and 6 part-time students to 14 faculty, we see little justification for yet another program. Any of the existing doctoral programs would appear a better base for expansion than either master's program.

Recommendation 7

Since all the Toronto programs are assessed as satisfactory, we see little justification for the inclusion of the clause '...which involve new appointments to certain of these groups', a clause which could be read to imply criticism of the present programs. This said, we intend, subject to budgetary constraints, to continue to make appointments to replace retiring staff and to seek the best persons available for these appointments. We can report for information that three tenurable appointments (in transportation, water resources, and structures) have been made for 1975-76.

Yours sincerely,

A.E. Safarian

A.E. Safarian
Dean

Encl.
AES/

DRAFT RESPONSE*

to

THE REPORT OF ACAP SUB-COMMITTEE ON CIVIL ENGINEERING, JANUARY,1975

by

Department of Civil Engineering
University of Toronto

March 10, 1975

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* Attached document will be part of the Department of Civil Engineering Response to the report of ACAP Sub-Committee on Civil Engineering. It contains information offered for the record, and does not include comments specific to the recommendations and judgements of the subcommittee.

GENERAL

The Concept of Graduate Education:

The concept of graduate education at the University of Toronto is characterized as much by its depth as by its individual strengths. A graduate student is able to find sound advice within the university structure on almost any topic. The ability of the University of Toronto to offer excellent Ph.D. programs is enhanced considerably by this diversity. Any evaluation of a particular Ph.D. progam must consider the relevant connections with other sections of the University. This is particularly true in Civil Engineering where the University and the Department have whenever possible avoided duplication of effort. The resulting division of responsibility for graduate programs in Engineering at Toronto is different from other universities. Therefore, any evaluation of a Ph.D. program in Civil Engineering at the University of Toronto must consider the activities in related programs for two reasons: 1) the academic merit of the program can be strongly related to other activities, 2) a complete program in Civil Engineering is not necessarily entirely contained within the Department.

The contribution of the Department of Civil Engineering to graduate education at the University of Toronto is directed specifically to the "engineering" or applied science aspects of knowledge related to structural, geotechnical, environmental and transportation engineering. This emphasis is in agreement with the philosophy of what constitutes an appropriate mix of engineering science and engineering practices as stated by the ACAP Report on Chemical Engineering. The following quotations are from Section 2.3 of that report:-

> ".....In Ontario as well as in the rest of North America, chemical engineering faculty have deployed by far the largest part of their research activities in chemical engineering science. This is not surprising, considering the policies of the most important granting agencies servicing the universities and the emphasis put on scholarly work which will lead to the diffusion of knowledge through publications in scientific journals as a requirement to a successful university career.
>
> "However, such research orientation plus university policies have caused a serious neglect of the more 'engineering' aspects.....
>
> ".....The advent of new granting programs, mostly of the mission-oriented type, should help to restore a more suitable balance between fundamental engineering research and research concerned with application and design in the universities....."

The members of the Department of Civil Engineering at the University of Toronto are active in areas of research and community involvement that relate directly to engineering practices. The importance and difficulties associated with applied research are described in another quote from

Section 2.3 of the ACAP Report on Chemical Engineering:-

> "In contrast to the situation in the various disciplines of pure science, where research associated with doctoral studies is almost invariably of a fundamental nature, additional research avenues are open to chemical engineering graduate students because of the very nature of engineering whose general purpose is 'to make' rather than 'to find'. Whatever these avenues are called - applied or mission-oriented research, development or design - they represent hard-to-define and overlapping realities."

A group involved in applied research and development of the profession can not be judged by the same criteria as a university scientist. Additional information related to contributions to applied and professional aspects of Civil Engineering should be included in an evaluation of its graduate program, and this should be made by appropriately qualified Civil Engineers.

History of Ph.D. in Civil Engineering at Toronto:

The first Ph.D. student in Civil Engineering was enrolled in 1957. According to the regulations of the School of Graduate Studies (SGS), of the University of Toronto, before 1966 each doctoral candidate in the Department of Civil Engineering was under the supervision of a committee set up by the SGS. The Department of Civil Engineering was empowered to administer its own Ph.D. program by the School of Graduate Studies in 1966.

Prior to being recommended to the School of Graduate Studies for final examination, each candidate must pass a Departmental Examination. To date, no candidate recommended by the Department of Civil Engineering has failed or had an adjourned final School of Graduate Studies Examination. The answer to the question of "is the program successful in educating and training Engineers" must in the final analysis be found in the contribution of our graduates to society.

Attached is a list of our 34 doctoral graduates, their background, present position, and the names and institutions of the external examiners. It must be noted that this list contains only the individuals who proceeded towards their degree through the Graduate Department of Civil Engineering. The list does not include individuals who proceeded through other graduate departments towards doctoral work, such as in Solid Mechanics, Hydraulics, and Materials Engineering.

RECIPIENTS OF PH.D. IN CIVIL ENGINEERING FROM THE UNIVERSITY OF TORONTO

	YEAR	NAME	FIELD	DEGREES FROM		PRESENT LOCATION & REMARKS	EXTERNAL EXAMINER		SUPERVISOR
				Bach.	Masters		Name	University	
1	1960	Yalcin, S.	Geotech.	Cornell	Cornell	Chairman, Dept. of Civil. Eng., Bogazici Univ., Istanbul (Robert College)	F.A. DeLory	Toronto	W.L. Sagar
2	1961	Kennedy, J.B.	Struct.	Wales	Toronto	Chairman, Dept. of Civil Eng., University of Windsor	D. Naylor (Mathematics)	Toronto	M.W. Huggins
3	1962	Nagy, D.	Geodesy	Sopron	Toronto		C.C. Barnes & F.S. Grant	Toronto	D.J. Marshall
4	1963	Robinsky, E.I.	Geotech.	Beirut	Harvard	Assoc. Prof., U. of Toronto	F.A. DeLory & C. Hershfield	Toronto	W.L. Sagar
5	1966	Divakaran, S.	Struct.	Andhra	McMaster	Commonwealth Scholarships	R.L. Ketter	Buffalo	D.J.L. Kennedy
6	1966	Laak, R.	Environ.	Manitoba	Toronto	Assoc. Prof. of University of Connecticut in Storrs	J. Winneberger	California	A.P. Bernhart
7	1967	Drysdale, R.G.	Struct.	Manitoba	Toronto	Assoc. Prof., McMaster Univ..	J.E. Breen	Texas	M.W. Huggins
8	1967	Khalifa, S.	Struct.	Punjab	New S.W.	Prof., Civ.Eng., Lahore U., Pakistan, Colombo Plan	M.P. Poucher	Western Ont.	M.W. Huggins
9	1967	Suter, G.	Struct.	Western	Toronto	Assoc. Prof., Civil Eng., Carleton University	S.D. Lash	Queen's	G.N. Kani
10	1968	Ghosh, S.	Struct.	Bengal	Toronto	Ontario Hydro	R.H. Mills	Calgary	M.W. Huggins J. Timusk
11	1968	Gill, A.S.	Geotech.	Punjab	Toronto	Geocon Ltd.	C.B. Crawford	NRC	F.A. DeLory
12	1968	Tay, D.	Struct.	London	Toronto	Ghana Gov. Scholarship, Sr. Lecturer, U. of Ghana, Now in Canada Consulting	L.G. Jaegar	McGill	G.N. Kani
13	1969	Smith, L.	Transp.	Roorkee	Toronto	Gov. of Trinidad, Ministry of Works, Commonw'th Scholarship	H. Irwin	Peat-Marwick (Industry)	R.M. Soberman
14	1970	Berndl, A.	Struct.	Toronto	Toronto	Consulting - Principal, Toronto	R.C. Tennyson (Aerospace)	Toronto	J. Schwaighofer
15	1970	Temple, M.	Struct.	Toronto	M.I.T.	Asst. Prof., U. of Windsor	R.C. Tennyson (Aerospace)	Toronto	R.A. Collins
16	1971	Frind, E.	Struct.	Toronto	Toronto	Asst. Prof., U. of Waterloo	R. Fox	Case Western	P.M. Wright
17	1971	Henry, G.	Environ.	Queen's	Princeton	Assoc. Prof., U. of Toronto	W.O. Pipes	North Western	P.H. Jones
18	1972	Chan, H.T.	Geotech.	Queen's	Queen's	Ministry of Environ. Ont. (Tor.)	C.C. Ladd	M.I.T.	T.C. Kenney
19	1972	Microys, H.F.	Struct.	Toronto	Toronto	Consulting Eng. - Toronto	D.P.Billington	Princeton	J. Schwaighofer
20	1972	Ola, S.A.	Geotech.	Western	Western	Phmadu Bella Univ., Nigeria	R.N. Yong	McGill	T.C. Kenney
21	1972	Ono, K.	Struct.	Kyoto	Kyoto	Consulting - Japan	C. Kesler	Illinois	R.H. Mills
22	1973	Keenan, F.	Struct.	Toronto	Toronto	Asst. Prof., Fac. Forestry, University of Toronto	S.P. Fox	Cdn.Forestry Service, Vanc.	K. Selby
23	1973	Natarajan, T.	Photogr.	Annamali	Roorkee Toronto	Professor, Roorkee, India Colombo Plan	S.H. Collins	Guelph	J. Vlcek
24	1973	Rainford, E.C.	Struct.	London	DIC Imp. College	Consulting Eng., Toronto	C. MacInnis	Windsor	J. Timusk
25	1973	Wu, H.	Struct.	New S.W.	Toronto	Ontario Hydro	J.E. Breen	Texas	M.W. Huggins
26	1973	Charghoury, E.	Struct.	E.P.C.	Paris	Assoc. Prof., Ecole Polytechnique, Montreal	Z.M. Elias	Washington (Seattle)	Committee
27	1974	Goel, A.P.	Struct.	Roorkee	Roorkee Toronto	Consulting Eng., Toronto	G.Abdel-Sayed	Windsor	J. Schwaighofer
28	1974	Michellepis, C.P.	Environ.	Alexandria	Toronto	Consulting Eng., Toronto	A.F. Gandy	Oklahoma	P.H. Jones
29	1974	Mitchell, D.	Struct.	Toronto	Toronto	Asst. Prof., Univ. of Washington, Seattle	P. Zia	N. Carolina State Univ.	M.P. Collins
30	1974	Lin, E.C.	Environ.	Chu Hai	U.N.B.	Asst. Prof., U.of New Brunswick	Eric Davis	Saskatchewan	G.W. Heinke
31	1974	Walker, T.	Struct.	Waterloo	Toronto	Research - Fac. of Medicine Toronto	Dr.Robt.Salter (Medicine)	Toronto	R.H. Mills
32	1974	Palmer, L.	Geotech.	Toronto	Toronto	Asst. Prof., Univ. of Western Ontario	Z. Eisenstein	Alberta	T.C. Kenney
33	1974	Krpan, P.	Struct.	Zagreb	Toronto	Consulting Eng., Toronto	T.T. Hsu	Miami	M.P. Collins
34	1974	Sethee, S.	Struct.	Punjab	Toronto	Consulting Eng., Vancouver	A.K. Naghdi	Purdue	J. Schwaighofer

Although the Department of Civil Engineering at the University of Toronto in its present form was established in 1920, Graduate Studies in Civil Engineering go back to the beginning of the 1900's. Until the end of 1974, 3789 Bachelors, 511 Masters and 34 Ph.D. degrees in Civil Engineering have been granted by the University of Toronto. The distribution of these graduates are given below:

		NUMBER OF DEGREES GRANTED		
Period		Bachelors	Masters	Ph.D.
1881 - 1919		889	7(first 1907)	-
1920 - 1929	(10 year period)	261	2	-
1930 - 1939		179	9	-
1940 - 1949		465	28	-
1950 - 1954	(5 year period)	517	57	-
1955 - 1959		412	48	-
1960 - 1964		398	86	4(first 1960)
1965 - 1969		319	118	9
1970 - 1974		349	156	21
	TOTAL	3789	511	34

A feature of the Department of Civil Engineering at the University of Toronto has been, and continues to be, a large and active undergraduate program. The size of the Department has allowed some staff to devote full time to undergraduate education while still providing a sufficient number of academic staff for research and graduate teaching to develop major programs in structural, transportation, geotechnical and environmental engineering. It is appropriate that the graduate program should be evaluated primarily on the program and staff at the graduate level; however, the active undergraduate program and staff that have chosen to concentrate on professional education at this level nevertheless make a significant contribution to the academic environment for graduate students in the Department.

Students:

Admission standards of the Department of Civil Engineering have been uniformly very high. No applicant is admitted to a Ph.D. program, unless he has completed his Masters degree and his work or his supervisor at Masters degree level is known to the staff of the Department. Otherwise, admission is granted only as Masters student.

The admission standards for Ph.D. enrolment have remained unchanged over a period of considerable fluctuation of applications for admissions and candidates of admissible standard. The Department has not been prepared, as indicated by the number of Ph.D. admissions per year, to change its admission standards in the light of diminishing numbers of students.

The table below shows the number of applicants, the number accepted and the number registered for the doctoral program for starting in September of the year indicated:-

Year	No. of Applicants	Admitted	Registered
1969	50	16	9
1970	42	16	10
1971	15	4	3
1972	21	7	5
1973	54	12	5
1974	56	8	2

Although there is a significant drop in recent years in the doctoral enrolment in Civil Engineering in Ontario, the proportion of doctoral students in Toronto as a fraction of the total Ontario enrolment is in fact increasing since 1971-1972, as shown in Figure 1.

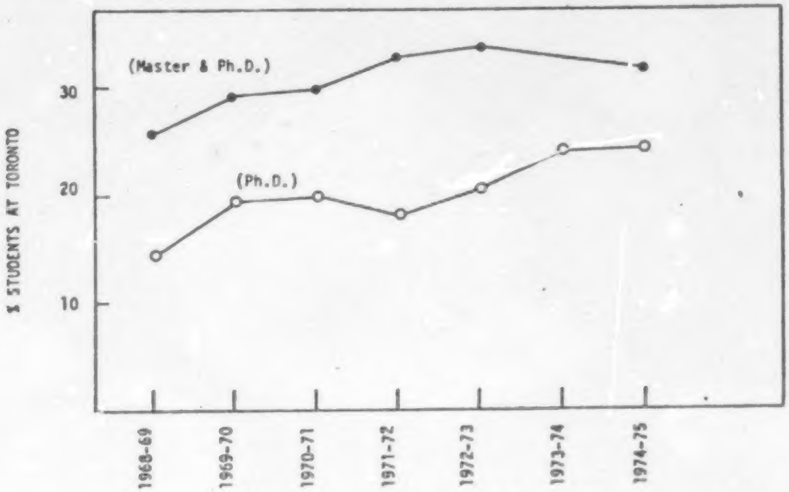

FIG. 1: Proportion of Number of Students at Toronto as % of Ontario Enrolments *

Other evidence of this rather strict admission policy is reflected in the proportion of full-time doctoral students in residence. As can be seen in Figure 2, the ratio of full-time doctoral students to the total full-time graduate students in Toronto has remained relatively stable and significantly below the proportion in the rest of the Ontario universities. We believe that, considering the rather "young" Ph.D. program in Civil Engineering in Ontario, the proportions at Toronto are realistic and in keeping with the needs of the society.

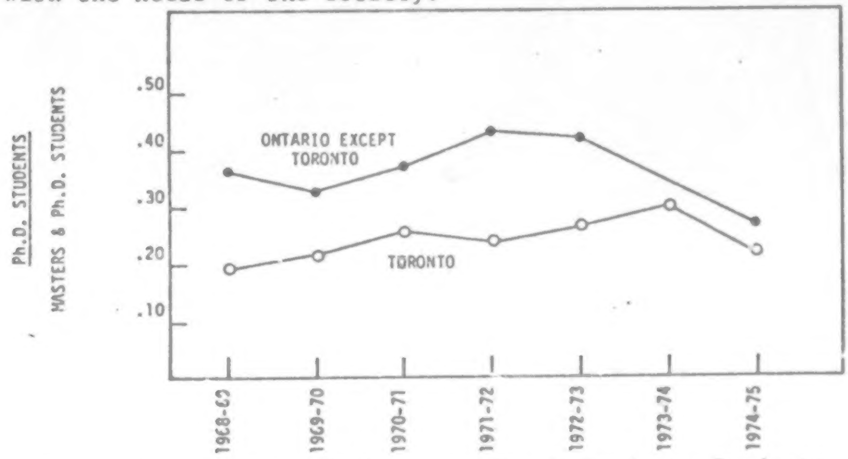

FIG. 2: Ratio of Ph.D. Students to Total Graduate Students (Full-time) *

A measure of the quality of graduate students may be the comparison of the proportion of the full-time students in Toronto receiving major grants [NRC Scholarships, other major scholarships (greater than $2500), NRC Bursaries, Ontario Graduate Fellowships and CIDA Fellowships], with the full-time students receiving major grants in the Ontario system except Toronto, as shown in Figure 3.

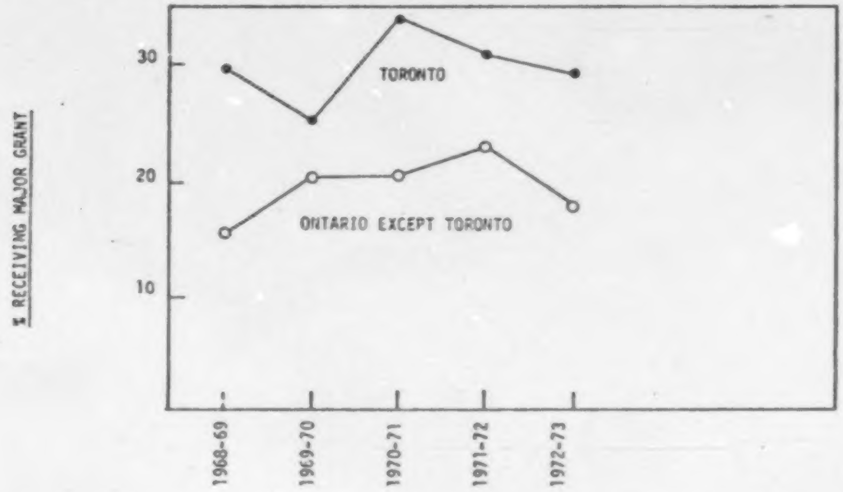

FIG. 3: Proportion of Total Full Time Graduate Students Receiving Major Grants*

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*Data from ACAP Documents dated April 18, 1973, ACAP Subcommittee Report.

General Resources:

A graduate student in Civil Engineering has access to several university resources that contribute to the strength of a Ph.D. program at the University of Toronto. One such important resource to applied scientists is the large and readily available computer facility. The most important aspects are the main terminal for access to the IBM model 370 computer which is considered to be one of the finest scientific computer installations in Canada. Free access to the high speed job stream and the availability of interactive terminals are other features of importance to Civil Engineers. A second important resource is the University of Toronto's library system, again one of the largest and most comprehensive in Canada.

A summary of professorial staff active in graduate education, and the amount of external funding (excluding equipment grants) is given below:

	1972-1973	1973-1974	1974-1975
Number of Professorial Staff	23.1	26.85	26.85
NRC Operating Grants:			
Number of Grantees	17	17	18
Amount $	$128,270	$126,570	$151,675
All other external funding	$228,605	$275,575	$335,900 (to date)
TOTAL EXTERNAL FUNDING	$356,875	$402,145	$487,575 (to date)

Relationship with the Profession:

The relationship of the Department with the Profession is excellent. Almost all members are registered Professional Engineers. As may be seen from detailed listings under the various sections, the staff contributes extensively to the development of the profession. The President of the Canadian Society of Civil Engineers and the President of the Canadian Geotechnical Society both are members of this Department.

Following is a detailed discussion of the Structures, Geotechnical, Hydraulics and Water Resources and the Transportation sections of the Department.

STRUCTURES

The major goal of the Structural Engineering graduate program at the University of Toronto is the education of professionals with special skills in design and research in structural engineering. In support of this objective, the research interests of the staff, as well as their outside professional activity, have a strong emphasis on design.

When planning the Civil Engineering facilities for the new Galbraith Building in the late fifties, this strong interest in design had a major influence on the type of facilities provided. The result of this planning is that the Department has the largest facilities for structural testing in Canada. These facilities, complemented by excellent computer and library services, have permitted the desired type of undergraduate and graduate program to develop.

The decision to encourage strength in structural design was taken with full cognizance of the areas of interest and skills of closely related disciplines in other Departments of Engineering at the University of Toronto. The composition of the present staff and continuing recruitment policy reflects this decision.

Members of the Department have ready access to and co-operate with their colleagues in Aerospace Engineering, Mechanical Engineering and the Materials Science groups in Chemical Engineering and Metallurgy. The existence of the above groups within the Faculty means that research in the areas of Solid Mechanics and Materials Science was and continues to be actively pursued in the Faculty and is supported in part by the Civil Engineering Structural Group. Some members of our staff have been closely associated with both Aerospace Studies and the Materials Science group.

Through the assistance of the Materials Science Development grant received by the Faculty of Applied Science and Engineering, the Department of Civil Engineering brought together an innovative concrete and composite materials group which strongly expanded the strength of the Faculty while building on existing strengths in the Departments of Chemical Engineering and Metallurgy and Materials Science.

The Department has strength in analytical and experimental structural research. Analytical interests are directed towards the problem oriented application of analytical tools and techniques. Experimental activity has a strong emphasis on large scale experimental verification of theory and a fundamental approach to development of structural materials. The goal of this work is the development and verification of theory, the incorporation of improved understanding of structural behaviour and materials into professional practice, and the invention of new materials and combinations of materials.

Analytical studies to be relevant and significant must be based on experimentally verified constituent relationships of the materials involved. The validity of the assumptions utilized in the mathematical modelling must be established and the analytical procedures must be judged on the ability to predict experimental behaviour. This calibration is absolutely essential if the results of analytical studies are to have the confidence of the profession.

It is an acknowledged fact that, as a result of the lack of reliable experimental evidence, the full potential of many new analytical developments has not been realized. In certain areas advances in analytical tools have far outstripped the capacity for experimental verification. Recognition of this fact is, in fact, demonstrated by many unfilled positions for "experimentalists" that now exist in North American universities and research organizations. Doctoral graduates having a reasonable balance between analytical and experimental skills are in considerable demand. As evidence of our strength in this context, it is pointed out that two of our recent doctoral students in Reinforced Concrete Structures have been engaged by the University of Washington in Seattle and the Portland Cement Association Research Laboratories in Skokie, Illinois, despite restrictive U.S. immigration policies.

The place that "Building Codes" have in the field of Structural Engineering is unique. Once adopted, they are legal documents. They are intended to represent the "best current practice". Presumably the goal of every "Structural" Engineering Researcher is to contribute to the improvement of structural design. That goal is what sets him apart as a Structural Engineering researcher.

A significant recognition of a Structural Engineering researcher is the acceptance of the fruits of his research by his peers. The most tangible evidence of this is the recognition of his research as the "best current knowledge", and incorporating his findings in part of a Building Code, Standard, Specification, or "Guide for Recommended Practice". This is the focus of most of the staff of the Structures Group of this Department.

The National Building Code of Canada is issued by the Associate Committee on the National Building Code of the National Research Council of Canada. In its 1975 edition the Code recognizes and acknowledges the contribution of 8 professors of Civil Engineering of Ontario universities. The distribution of these professors is 3 from Toronto and one each from 5 other universities.

The American Concrete Institute (ACI) is an international organization recognized as the foremost technical organization in the world dealing with concrete. The Building Code it publishes is used as a model and source throughout the world. The basic mechanism of ACI's technical development is its Technical Committees which have international membership. Currently, 17 Civil Engineering faculty members of Ontario universities are appointed members of these committees; the distribution of these professors is 6 from Toronto with varying numbers up to 3 each from 6 other universities in Ontario.

Further contributions are made by the staff of this Department to the technical committees of the American Society of Civil Engineers and other national and international organizations, such as: Canadian Standards Association, Research Council on Riveted and Bolted Structural Joints of the Engineering Foundation, American Society for Testing and Materials, RILEM, International Association of Bridge and Structural Engineers, ICES Group, and the Bio-Materials Society. Some of these contributions are summarized at the end of this section.

The three professors (1 professor, 2 associate professors) interested in materials have made important contributions to fundamental knowledge of the behaviour of cements and have also been responsible for innovations in composite materials and in conversion and use of waste materials to building purposes. Future material shortages in industrial countries are predicted by many authoritative sources. If materials used in buildings are to be conserved, it is essential that the design of the enclosure, which includes thermal design, moisture control and development of new materials, receive increasing attention. In this regard there are very close links among the staff interested in materials in Civil Engineering and the staff in other departments, mainly through the Systems Building Centre (SBC).

Much of the work in enclosure design and new materials has not yet been published because they have been, or are in the process of being patented by the University and various industries. There is the concern that publication at this stage may jeopardize the patents and commercialization.

Another example of innovative work is the development of new prosthetic devices from composite materials, which is being carried out in co-operation with an orthopaedic surgeon and a professor of Surgery. The first successful product is a new improved surgical cast material which is being commercialized under licence from the University of Toronto by a Montreal firm.

The Systems Building Centre provides an excellent means of involving the Civil staff with research and development problems of Industry and Government. The Centre has its own full time support staff of research engineers, a technician and a combined secretary, librarian and accountant. Through this full time staff assisted by Masters, Ph.D. and summer students and close associations with staff in Mechanical and Chemical Engineering, members of the Civil Engineering staff have been able to do important research and development in the area of new construction materials and methods, and some of this work has received world-wide publicity (e.g. the patented tape program). The activities of the SBC are an integral part of the total structural and materials research effort of the Department and the Faculty, and has significantly contributed to the engineering oriented research atmosphere in the Department.

Problems dealt with through the Centre and almost entirely by Civil Engineering staff, include the following: extensive work on the application of the "tape" system for producing pipe, wall panels, waterproof membranes for bridge decks (for protection from salt corrosion) and strongly supported financially by the Ministry of Transportation & Communications of Ontario; a thorough feasibility study of a novel new type of building known as an Isothermic Building, which offers potential for energy conservation in building heating and cooling and is also being supported by a substantial grant from the Ministry of Energy of Ontario.

As an indication of the significance attached to the type of activity undertaken by Civil Engineering staff in the SBC, the following paragraph has been taken from the report "Research for Construction" by N.B. Hutcheon, Director of the Division of Building Research, National Research Council of Canada, published in March, 1974 (NRC 14005). Reference is to the University of Toronto:

> Professional engineering education in universities has had little concern for buildings, apart from the contributions of the specialties of structures and structural materials, air-conditioning, lighting and electrical engineering. The traditional division of design responsibility between the architect and the engineer which this situation reflects was discussed at some length in Chapter 5. An effort has been made at one university on the initiative of its department of civil engineering with the establishment of a systems building centre. It provides a focus for faculty members interested in building subjects and brings them together voluntarily on a multidisciplinary basis in the course of providing instruction and research direction for civil engineering graduate students. The centre functions also as a construction research institute, soliciting support from industry for appropriate research projects to be carried out at the centre by staff and graduate students.

Summary of Activities:

The Structural Group of the Civil Engineering Department of the University of Toronto consists of 13 professors active in graduate education, (5 professors and 8 associate professors). Very diverse backgrounds, engineering experience, research interests and age distribution of the staff are enriching ingredients for a balanced program. To date, 22 Ph.D. degrees have been awarded in Structures, the first being in 1961 and half of the graduations have occurred from 1972 on.

External Funding:

Research funding is obtained in the form of operating grants from NRC, and in various forms of grants and contracts from sources such as the Federal Department of Industry and Commerce, Ministry of Transportation & Communications of Ontario, Canadian Institute of Steel Construction, and National Research Council, and various industrial concerns. A summary of these funds (excluding equipment grants) are given below:-

	1972-1973	1973-1974	1974-1975
Number of Professorial Staff	12	13	13
NRC Operating Grants:			
No. of Grants	8	9	9
Amount $	$ 70,100	$ 74,000	$ 87,200
All other External Funding	$120,900	$183,405	$190,300 (to date)
TOTAL EXTERNAL FUNDING	$191,000	$257,405	$277,500 (to date)

Figures shown for 1972-73 and 1973-74 include a grant of $100,000 per year to the Systems Building Centre (last two years of a three year grant) by the DITC. The 1974-75 figures include the first significant instalment ($68,548) of a special four year grant totalling $154,123 from the National Research Council of Canada to the University of Toronto, for the instrumentation of the CN Communication Tower. The Grant is for a co-operative program involving 7 members of the Department of Civil Engineering, the Division of Building Research of NRC, Canadian National Railways, Air Quality Branch of Environment Canada and the Boundary Layer Wind Tunnel Laboratory at the University of Western Ontario.

It is of interest to note that when 1974-75 NRC operating grants are examined in the categories of:

4205 - Behaviour and Design of Concrete Structures
4206 - Behaviour and Design of Steel and Timber Structures
4207 - Industrial Building, New Structural Systems
4208 - Building Science, Fire Resistance, Cladding & Insulation
4209 - Engineering Properties of Construction Materials
4212 - Construction Methods and Techniques

which are in the areas of concentration of effort of this Department, it is seen that the average grant to 7 grantees in the Department of Civil Engineering in Toronto is $10,210, which is the highest in Ontario and is exceeded in Canada only by the group at the University of Alberta.

Staff:

The quality of a program critically depends on the quality of the faculty. The appropriate means of establishing research quality may vary from discipline to discipline as well as varying from individual to individual depending on the nature of his activities. Irrespective of any differences that may be present, the fundamental principle involved in determining quality is through peer evaluation.

In some fields the best means of demonstrating quality of research is through publications in refereed journals. In Structural Engineering there are mechanisms in addition to publication in refereed journals that demonstate quality and significance of research.

The critical evaluation research results must undergo to influence and to appear as part of a technical committee report, or recommended practice is a broadly based system of peer judgement of considerable significance.

Another significant peer evaluation is the wide acceptance and use by practising engineers of the results of the research in the form of manuals, reports, design aids, etc., which are often not in a form suitable for journal publication.

The appointment of a researcher to a technical committee charged with preparing design recommendations which will involve critically evaluating all current research and engineering information is an indication of the individual's standing amongst his peers.

a) Publications and Patents:

In the past three years the members of the Structural Group have published 15 papers in refereed journals, 19 as conference proceedings where in some cases papers were refereed in full, have given 22 invited lectures, in addition have presented 25 papers in conferences, have published 17 other items such as research reports, discussions, articles, etc. Three staff members are currently editors of proceeding volumes, and two memorial volumes.

6 staff members have acted as referee for the ASCE Structural Journal, 4 for the ACI Journal, 3 have acted for 4 other international publications and 8 have acted as referee for Canadian Journals. One member of staff is editor of an international journal. In addition, almost everyone has acted as referee for CANCAM abstracts.

As a result of the work in composites in the past 4 years, 5 patents have been granted or pending (2 in 14 countries, 1 in 16 countries, and 1 in 8 countries).

b) Technical Committee Activities:

The extent of activity of the members of the staff in Canadian and International Technical Committees can be seen from the current listing given below:

	No. of Staff	No. of Committees
Canadian Technical Committees		
CSA/NBC Concrete Code	3	3
CSA, NRC, CSCE Committees	3	4
International Technical Committees		
American Concrete Institute	6	10 (3 Joint with ASCE)
American Society of Civil Eng.	5	5 (3 Joint with ACI, 1 Joint with IABSE)
American Society for Testing and Materials	1	2
Réunion Internationale des Laboratories D'essais et de Recherches sur les Materiaux et les Constructions (RILEM)	1	1

	No. of Staff	No. of Committees
Research Council on Riveted and Bolted Structural Joints of the Engineering Foundation	1	4
Bio-Materials Society	1	1
International Association of Bridge and Structural Engineers	1	1 (Joint with ASCE)

In summary, 10 staff members are active in technical committees, with 8 being members of International Committees. In addition, one member is the Canadian delegate to RILEM and another is one of the two Canadian delegates to Comite Europeen du Beton (the other from University of Alberta).

c) External Recognition of Professional and Research Activities:

Given below are a few examples of the external recognition received by the members of the structures group:

A member of the structures group

- Served twice (about 10 years) as the Chairman and once (about 5 years) as member of the CSA/NBC code committee in Reinforced Concrete Design.
- Was the Chairman of the committee which produced the first standard in North America on design of pre-stressed concrete structures.
- Was responsible for the formulation of the torsion provisions of the Canadian Reinforced Concrete Code (CSA A23.3 - 1973), which are based on his work.
- Serves on the Research Council on Riveted and Bolted Structural Joints of the Engineering Foundation (one of two from Canada and other from University of Alberta), and is a member of its 4 subcommittees including the Specifications Committee.
- Has his work cited over 20 times in the recent book "Guide to Design Criteria for Bolted and Riveted Joints", by J.W. Fisher and J.H.A. Strink, John Wiley & Sons, 1974.
- Was instrumental in significant changes in the proposed seismic design section of the Canadian Reinforced Concrete Code Chapter 19 (CSA A23.3 - 1973).
- Has contributed to the ACI-ASCE Committee on "Joints and Connections in Monolithic Concrete Structures" arriving at new design guidelines for reinforced concrete frames in high seismic risk areas which in significant portions are based on the results of his research.
- Has contributed to the better understanding of the behaviour of Glued-Laminated timber members and his research resulted in alteration of allowable stresses in British Columbia.

- Was co-author of a paper presented at the Forest Products Research Society Annual meeting in Annaheim, California. The paper was the winner of the 1973 Second Wood Award competition.
- Presented 2 papers at the seventh Congress of the Federation Internationale de la Precontrainte in New York (1974). Of the 148 technical contributions (refereed on the basis of full papers) 5 were from Canada.
- Presented an invited paper at an International Symposium in San Francisco on "Reinforced Concrete Structures in Seismic Zones" sponsored by the American Concrete Institute and the Structural Engineers Association of California. Of the 17 papers presented, 6 were invited, 1 was from Canada.
- Is a member and director of the ICES Users Group Inc., a group of about 600 institutional members, users of very large and complex systems of computer software. His work as represented by the up-to-dateness and the quality of the system at Toronto is recognized and used by 4 Ontario universities and the Ministry of Transportation & Communications of Ontario.
- Has 4 of his publications cited as part of a selected bibliography of 29 references given by the European Design Manual for Torsion (CEB Manuel de Calcul-"Torsion", Oct. 1973).
- Has co-authored the first design hand-book on Prestressed Concrete in North America.
- Has co-authored the "Strudl II-CSA S16 User's Manual" published by the Canadian Institute of Steel Construction.
- Is an Editor of the International Journal of Cement and Concrete Research.
- Is Editor of Chapter 24 of the Tall Building Monograph (IABSE-ASCE).
- Is a member of the Permanent Commission of RILEM.
- Was the Canadian alternate delegate to CEB (Comite Europeen du Beton).
- Has served as the Chairman of the Technical Activities Committee of the Canadian Society of Civil Engineers and is Chairman of the Technical Operations Board of the Engineering Institute of Canada.

An evidence of the quality of our students and success of the staff to impart design awareness and excellence is the recent recognition five of our graduate students have received in the North America wide Prestressed Concrete Bridge Design competitions conducted by the American Prestressed Concrete Institute. Of the three entries submitted from Toronto, two placed first in two successive years and one received honorable mention "For excellence in Prestressed Concrete Bridge Design".

Members of the group have acted as consultants to all levels of Government and private industry, both in Canada and elsewhere.

GEOTECHNICAL

Geotechnical Engineering is concerned with the engineering properties of the earth materials such as soil, rock, muskeg, ice and snow and the use of the materials as part of engineered structures. The earth material might be the support for the structure, the material of the structure itself as in an earth-rock dam or the load on the structure, as on a tunnel lining. In all cases the properties and action of the earth materials must be known for safe and economical structural design. Geotechnical engineering is thus the bridge between geology, the scientific study of the earth materials and structural engineering, which uses man-made materials usually manufactured from earth materials.

At the University of Toronto the Geotechnical Section of the Department of Civil Engineering has major responsibilities in two undergraduate teaching programs, 1) Civil Engineering, 2) Geological Engineering and Applied Earth Science, and in the graduate program in Geotechnical Engineering within the Department of Civil Engineering. The responsibilities include the teaching of courses in soil mechanics, foundations, rock mechanics, design of earth and rock structures, pleistocene geology, air photo interpretation, groundwater and engineering geology.

As Geotechnical Engineering is based on earth materials, and for a large proportion of cases these materials must be accepted in their natural state, a good deal of Geotechnical Engineering is involved with the determination of the properties of the natural materials that may be involved in a project and how the material may be used or act as part of an engineered structure. In some cases the improvement of the properties of natural materials is of major importance.

From the foregoing it is apparent that Geotechnical Engineering must be orientated towards material properties under field conditions. Therefore the Geotechnical Section directs its teaching and research to the solution of practical problems of local and Canadian importance in the field of Soil Mechanics, Foundations and Rock Mechanics. In the research area the major emphasis is on field behaviour and physical characteristics of earth materials as they related to engineered structures, (e.g., buildings, tunnels, dams) and to natural phenomena, (e.g., landslides, frost action). Because of this emphasis much of the research is experimental and measurement work in both the field and laboratory.

This type of research work has led to the development of laboratories and equipment that are consistent with the research objectives. The laboratory facilities are comparable with any in Canada. The soil mechanics laboratory, in addition to the basic equipment of high quality and diversification, contains equipment such as a direct shear device, that is not found elsewhere in Canada. The foundation laboratory which includes a test pit 12 x 14 x 28 ft. is the only installation of its size and type in Canada. It allows the testing of half size foundations on or in sand placed to a carefully controlled density. A rock mechanics laboratory is currently being set up with monies provided by the University for a laboratory in a new area of study. The group is equipped to do field studies and usually has several in progress at any time.

Interaction:

The research leads to an interaction with other parts of the University and with the construction industry including consultants to that industry. In the first case the interaction is with the Departments of Geology and Geography because of the materials involved and the study of natural phenomena. In the case of the construction industry and consultants it is often necessary to receive their cooperation in the study of real problems associated with the use of earth materials.

Examples of recent or current direct interaction with industry are:

- Co-operative work is being done with industry and the structures and materials section on the design of insulated foundations. A new concept, developed by a staff member, to reduce the cost of foundations, has been used for 14 major industrial buildings and structures. This work has been supported and used by two major mining companies operating in Northern Ontario and Quebec.
- Elastic-plastic static and dynamic behaviour of Toronto Shales. The foundation rock beneath the CN tower has been instrumented. Data collection is continuing.
- Environmental protection against oil spills for tank farms across Canada. A new approach developed by a staff member is now under test in Ontario.
- A novel environment protecting concept developed by one of our staff members for the discharge and disposal of tailings from mining operations has been adopted by at least two mines in Canada and one in the United States. The results appear favourable and are now being assessed.
- A research program has just been completed to investigate the loads and deformations of permanent and temporary tunnel linings in the Toronto area. It was shown that considerable savings in tunnel design could have been achieved on this project and therefore the information is vital for future similar construction.
- Measurements of earth pressure on a large strutted excavation have been completed recently at one site and are continuing at another site and measurements of pressures in a large cement clinker silo are currently being taken to provide assistance in future design.

Summary of Activities:

The staff members in the Geotechnical Section are five full-time members and one, who has a 40% cross appointment with the Faculty of Forestry. One of the full-time members was appointed in October, 1973 and one in November, 1974. The staff has been selected so that there is a coverage of and a balance between the areas of soil mechanics, foundations, engineering geology, rock mechanics and air photo interpretation. By design there is overlap in the areas and interest of the staff. The acceptance of the staff both within and outside of Canada is indicated by the following positions that are or have been held:

- First Laurits Bjerrum Memorial lecturer - an invited lecture in Norway of international stature, honouring the former President of the International Society of the Soil Mechanics and Foundations.
- W. L. Huber, Research Prize of the American Society of Civil Engineers (First Canadian to be awarded the prize).
- Chairman, NRC Sub-Committee on Soil Mechanics.
- President, Canadian Geotechnical Society.
- Chairman, Literature Classification and Information Retrieval Committee, International Society for Soil Mechanics and Foundation Engineering.
- Member, editorial board, Canadian Geotechnical Journal.
- Editor, Canadian Geotechnical Journal.

Membership on the following committees as examples:

- NRC Associate Committee on Geotechnical Research.
- American Society of Civil Engineers, Research Committee of the Geotechnical Engineering Division.
- International Society for Rock Mechanics Committee on teaching Rock Mechanics.
- Forestry sub-committee of the Canadian Committee on Remote Sensing.

Recognition by industry is evident from the consulting work of an unusual and original nature carried out. Examples are:-

- Principal Consultant for foundation investigations and foundation design of CN Tower.
- Complete feasibility study for a mine in northern Baffin Island, including dock, air strip, town site, water supply, rods, etc.
- Evaluation of safety of a shipyard launching berth and recommendations for remedial work.
- Site investigations, siting of mine and concentrator buildings and structures, and recommendations for design of all foundations and tailing dams for the largest mining complex constructed in Ontario in recent years.
- Evaluation of three existing town sites on Baffin Island and recommendations for expansion, construction of dock and air strip and water supply.
- Design recommendations for rehabilitation of Imperial Oil tanker dock at Britt, Ontario.

Funding:

Currently staff members are supported on research projects by National Research Council operating grants and other research funding as indicated in the table below. One staff member has not been with the Department long enough to receive grants.

	1972-1973	1973-1974	1974-1975	
Number of Professorial Staff	3.6	4.6	5.6	
NRC Operating Grants:				
No. of Grants	3	3	4	
Amount $	$26,500	$28,000	$32,975	
All Other External Funding	$29,000 *	$ 8,300	$ 5,800	(to date)
TOTAL EXTERNAL FUNDING	$55,500	$36,300	$38,775	(to date)

* Includes a PRAI grant of $24,000 that extended over the following two years.

Publications:

The section has produced eleven papers in refereed journals in the past three years and 19 others including seven in conference proceedings in the same period.

HYDRAULICS AND WATER RESOURCES

The major goal of the Environmental Engineering program at the University of Toronto is professional education and research in water quality and quantity management with a minor program in air pollution. All five staff members have many years of full-time professional experience as well as research experience. The decision to concentrate on water quality and quantity management, referred to in the ACAP sub-committee report as water resources, was taken in full cognizance of the areas of interest and expertise of closely related disciplines in other Departments of Engineering at the University of Toronto. The two most important contributors outside the Department of Civil Engineering are the Department of Mechanical Engineering and the Institute of Environmental Studies.

At the University of Toronto hydraulic engineering has always been an important facet of a very comprehensive program in fluids science, which is administered by the Department of Mechanical Engineering. Because of the close interdepartmental co-operation in this area, graduate students in Civil Engineering can specialize in hydraulic engineering at the Master's and Ph.D. degree level. Research facilities are accommodated in four fluids laboratories with a combined floor area of over 27,000 square feet. Major pieces of apparatus include two self-contained 25-cfs water supply systems, three open channel flumes, a 200-ft. towing channel and five wind tunnels. Two of the latter are micro-meteorological facilities suitable for research in building aero-dynamics and air pollution control. This cooperative program was formulated in 1970. One of the staff members in Mechanical Engineering (himself a Civil Engineer) is formally cross-appointed to the graduate Department of Civil Engineering as liaison. At least six of their staff are involved in graduate teaching and research programs in hydraulic engineering. The personal information on these staff members are available through the submission to ACAP of the Department of Mechanical Engineering.

The Institute of Environmental Studies was formally established in 1971. The Department of Civil Engineering played a very significant role in this, particularly through the leadership of one of its staff members, who was the first Director of the Institute from 1971 to 1973. He is now cross-appointed half-time to the Institute. The other Civil Engineering staff members have had significant interaction with the Institute in teaching and research of an interdisciplinary nature, and are Associates of the Institute. Many of our graduate students, at both the Master's and Ph.D. level, take part and benefit considerably from the course offerings and research activities in the Institute. In summary, there can be no doubt that the presence of the Institute of Environmental Studies add substantially to the capability of the Department of Civil Engineering to offer graduate programs at the Master's and Ph.D. level in Water Resources, and in reverse that the staff of the Department of Civil Engineering is an important contributor to the overall capability of the Institute.

Summary of Activities:

The Environmental Engineering Group of the Civil Engineering Department of the University of Toronto consists of 5 professors active in graduate education (2 professors and 3 associate professors). To date, 4 Ph.D. degrees have been awarded in Environmental Engineering, the first in 1966, all others from 1971 on. There are well equipped laboratories of about 10,000 ft.^{2} In addition the sewage treatment plant at Penetanguishene is available for plant studies. Through the Canada Centre for Inland Waters pilot plant facilities are available and have been used for 1 Ph.D. project.

Funding:

Research funding is obtained in the form of operating grants from NRC, and in various forms of grants and contracts from sources such as the Federal Departments of the Environment, Agriculture, Supplies and Services, Indian Affairs and Northern Development, and from provincial, municipal and industrial sources. A summary of these funds is given below:-

	1973-1973	1973-1974	1974-1975
Number of Professorial Staff	4	5	5
NRC Operating Grants:			
Number	2	2	3
Amounts $	$12,000	$12,000	$ 19,500
All Other External Funding	$36,000	$35,600	$ 82,400* (to date)
TOTAL EXTERNAL FUNDING	$48,000	$47,600	$101,900 (to date)

* This includes 2 contracts (total of $53,000) held jointly with another staff member not in Civil Engineering.

In the past three years the members of the Environmental Engineering Group have published 16 papers in refereed journals, 14 in conference proceedings, some of which were refereed in full, authored 1 book, and have given 18 invited lectures, have presented 11 papers at conferences, and have published 19 research reports.

The acceptance of the staff both within and outside Canada is indicated by the following positions/awards that are or have been held in the recent past:

- Vice-Chairman, World Environment Resources Council
- Consultant, World Health Organization
- Chairman (Civil), Technical Operations Board, EIC
- Member, Canadian-Soviet Working Group on Northern Engineering
- Fellow, Royal Society of Health
- Referees for Journals of Canadian Society of Civil Engineers, American Society of Civil Engineers, Water and Pollution Control
- Award of Heineman Prize (Germany)

TRANSPORTATION

The University of Toronto is fortunate to have a large group of academic staff from many disciplines applying their teaching and research efforts to transportation problems. Disciplines with a major commitment to transportation issues include economics, geography, management studies, planning and several branches of engineering. The Department of Civil Engineering has chosen to develop a transportation engineering program that complements the university wide activities in graduate studies in transportation. A Ph.D. candidate in the Transportation Section of the Department of Civil Engineering is required to become involved in the graduate program of at least one, and most often two, disciplines related to transportation but outside of the Department. Therefore, the strength of the Ph.D. program in Transportation within Civil Engineering is intimately related to the activities in transportation throughout the University.

The emphasis of Civil Engineering's graduate program in transportation has been to provide the transportation engineering and quantitative transportation planning components to a major program in transportation related topics at the two Toronto Universities. Although a student registers and specializes in a particular discipline, such as Civil Engineering, an important part of his program occurs outside that discipline. This principle was established in the belief that the best transportation professional is one with a disciplinary strength which is complemented by some understanding of other contributions to transportation problem solving. This interdepartmental participation has been found to be the case during the past few years with doctoral students from other disciplines taking Civil Engineering courses and our graduate students taking courses outside the Department.

The larger program in transportation studies is co-ordinated by the University of Toronto-York University Joint Program in Transportation.

The University of Toronto-York University Joint Program in Transportation was developed through financial support from the Federal Government. The Federal Government's objectives were to establish a small number of centres in Canada that would develop a significant academic program and research capabilities related to transportation issues. The resulting Joint Program, established in 1970, has successfully developed and academic program in transportation and created an active interdisciplinary research environment. The Federal Government has reviewed the activities of the Joint Program twice and increased the level of funding on each occasion. The present financial support of the program is approximately $250,000 per year, which is by far the largest in Canada. The important features of the Joint Program to graduate students, apart from the increased interaction between people of different disciplines with a common interest in transportation, are in four categories:-

1) the coordination of graduate courses in transportation,
2) the operation of a transportation information service with staff experienced in locating information related to transportation topics,
3) the student support grants for student research related to transportation,
4) possible participation in the wide variety of interdisciplinary and individual research projects on transportation topics.

The Department of Civil Engineering has always played an active role in the Joint Program. At present, two members of Civil Engineering serve on the small executive committee that administers the Joint Program.

Other examples of interdisciplinary activity in transportation at the University of Toronto are the recently developed graduate program in Guided Ground Vehicle Engineering and a newly established transportation option in the graduate program of the Faculty of Management Studies. Both teaching programs have important and specific input from the Department of Civil Engineering.

The transportation group in Civil Engineering have structured a graduate program that takes into consideration the contribution that can be made by Civil Engineers to the larger academic program in transportation studies. In general, the Civil Engineering program relates the present state of the art in transportation engineering and transportation planning to current transportation issues through a set of formal courses. In addition, the deficiencies of the current state of the art and potential improvements (through research) are explored in some specialized courses and through the graduate seminar series. The importance and relationship of the Department's program can be seen from the list of 42 transport related courses put out by the Joint Program of which 11 are from Civil Engineering. A summary of the course list is attached. The Civil Engineering program is kept current and maintains an interaction with the profession by offering materials of current interest in courses which are available to professionals and graduate students. These courses have proven to be very successful and have been offered in:-

Airport Planning (published readings now available)
Public Transport Planning (readings being prepared)
Dynamic Design for Road Safety (with Institute of Traffic Engineering)
Traffic Signal System Optimization (to be repeated)

Graduate students specializing in transportation engineering and transportation planning have a unique opportunity at Toronto of direct access to one of the finest urban transportation laboratories in North America - the Toronto transportation system. The existing system plus current large scale transportation experiments are considered so valuable to graduate studies that the Department has developed an innovative course that concentrates entirely on field measurements on the Toronto transportation system.

Prior to 1970, the transportation group was small and concentrated on undergraduate teaching plus a Master's degree program. Only one student graduated with a Ph.D. during that time. Since 1970, the staff in transportation engineering and transportation planning has expanded to the current complement of: one Professor (part-time)
three Associate Professors
one Lecturer.

This group has structured a graduate program with the explicit anticipation of attracting both Master's and Ph.D. students. There are currently four registered Ph.D. students.

Students and research efforts have been supported through grants and research contracts from a variety of sources including:

National Research Council
Federal Ministry of Transport
Provincial Ministry of Transportation & Communications
Toronto-York Joint Program
Roads and Transportation Association of Canada

	1972-1973	1973-1974	1974-1975
Number of Professorial Staff	3.5	3.25	3.25
NRC Operating Grants:			
No. of Grants	4	3	2
Amount $	$19,670	$12,570	$12,000
All Other External Funding	$42,705	$48,270	$57,400 (to date)
TOTAL EXTERNAL FUNDING	$62,375	$60,840	$69,400 (to date)

The transportation staff are active in individual research, contract research, and professional practice. Since 1971, the results of individual research have appeared as 9 publications in refereed journals and 11 publications in other forms. The group was responsible for major contributions, organization and editing of a set of readings on airport planning. A recent Urban Transportation Planning Guide to be published by the Roads and

Transportation Association of Canada was edited by a staff member. Contract research has been carried out by staff members for a variety of agencies including, the Federal Ministry of Transport, the Provincial Ministry of Transportation and Communication. The transportation staff currently serve on 3 national committees and 2 international committees in the transportation area. Staff_members recently have been called upon to referee papers in the following journals: Transportation Science, Transportation Research, Journal of Operations Research, Transportation Research Board and INFOR Journal. In addition, one staff member acted as a referee for papers submitted to the Sixth International Symposium on Transportation and Traffic Theory (Sydney, Australia, 1974) and presented one of the two Canadian papers at that Symposium.

A member of this Section, while Director of the University of Toronto's Centre for Urban and Community Studies, was seconded by a committee of local and provincial officials to direct a major review of transportation planning in Metropolitan Toronto. Another member of this Section is currently the Associate Director of the Centre for Urban and Community Studies with responsibility for transportation activities. The transportation staff in Civil Engineering contribute to and are kept current with the rapidly changing practice of transportation engineering by acting as advisors and consultants to a variety of public and private agencies. These agencies have included international (World Bank), national (Federal Government), provincial (Provincial Government) and local agencies.

GRADUATE COURSES IN TRANSPORTATION

This list was prepared by the University of Toronto-York University Joint Program in Transportation for distribution to graduate students and contains only courses that relate directly to transportation. The list does not contain courses related to the fundamentals of a discipline that are important to an academic program in transportation, i.e. economic theory, operations research methods, statistics, etc.

UNIVERSITY OF TORONTO

Institute for Aerospace Studies:

2020X	Flight Transportation Technology
2021X	Seminar in Flight Transportation
2035X	Human Control of Flight Systems
2040X	Stability and Control of Aircraft
2052X	Seminar in Human Control & Flight Systems

Department of Chemical Engineering:

1121X	Pipeline Transportation

Department of Civil Engineering:

1032X	Traffic Engineering
1033X	Transportation Operations
1034X	Transportation Planning
1035X	Land Use/Transportation Forecasting
1037X	Simulation Techniques in Transportation
1038X	Transportation Demand Analysis
1039X	Transportation Systems Evaluation
1085X	Airport Planning and Design
1089X	Case Studies in Urban and Regional Transportation Planning
1090X	Measurements on Transportation Systems
1091X	Characteristics of Public Transit Systems

Department of Geography:

1603X	Transportation Systems
2603	Advanced Seminar in Transportation Geography

Department of Industrial Engineering:

1151F	Production of Natural Resources

Faculty of Management Studies:

2405X	Logistics Management
2412X	Structure and Application of Network Flow Models
2414X	Logistics Problems in Resource Development

Department of Political Economy:

3100	Economics of Transportation

Department of Urban and Regional Planning:

1013X	Transportation

YORK UNIVERSITY

Faculty of Administrative Studies:

612	Economic Effects of Government Regulation
600	Canadian Transportation Issues
661	Transport Planning, Policy and Management
670	Energy Planning, Policy and Management
690	Management Science in Transport System Design

Department of Economics:

545	Transport Economics
547	Urban Economics
548	Regional Economics
546	Energy Economics

Faculty of Environmental Studies:

646	Transportation Theory and Method
678	Case Studies in Metropolitan Toronto
690	Workshop in Transportation
790	Advanced Workshop in Transportation

Department of Geography:

531	Transportation Geography
535.3	Energy Resources and Management

Osgoode Hall Law School:

239.3	Transportation Law and Policy

Department of Political Science:

542	Public Policy in Canada

RESPONSE OF THE UNIVERSITY OF WATERLOO
TO THE REPORT OF THE ACAP SUBCOMMITTEE ON CIVIL ENGINEERING
TO THE ADVISORY COMMITTEE ON ACADEMIC PLANNING
SUBMITTED TO ACAP, MARCH 21, 1975.

The University of Waterloo finds this Report generally acceptable. We have no general comments to make but do have a few specific comments on those parts of the Report that refer to the programmes at the University of Waterloo.

The University is pleased to note the recognition of the international stature of its Structures Group.

We feel that the Committee has underestimated the strength of the activity in the geotechnical area. While the Group is itself small, it receives substantial support from members of the Structures and Mechanics Group whose work falls in areas related to activities in the geotechnical field. The resources available to graduate students studying in this field are, therefore, considerably stronger than is indicated.

The section devoted to the Transport Group contains data which is not accurate. This is not the fault of the ACAP Subcommittee. Due to an oversight, the c.v.'s of the members of this group were not updated last October when the data was submitted to ACAP. This oversight was not uncovered until the Report appeared quoting the figures on grants and publications which the Group then recognized as not being accurate. Therefore, we have included with this submission updated c.v.'s from the members of this Group so that the Subcommittee will have access to the latest information. We suggest that the Subcommittee re-examine the data and correct the figures which it quotes in the Report. On the basis of this updated information, the Subcommittee might also wish to reconsider its overall assessment of this Group. We feel that the Transport Group at Waterloo is the strongest in this field in Canada and one of the strongest on the Continent.

One inaccuracy remains to be cleared up; the Group consists of five faculty: Professors Hutchinson, Haas, Yagar, Shortreed and Edens, not seven as reported in the Report. Also, we feel that it is somewhat misleading to refer to the activities of this Group as having a distinct planning bias. There is, to be sure, a good deal of cooperation between the Transport Group in Civil Engineering and members of faculty in the Faculty of Environmental Studies who are involved in problems dealing with urban and regional planning. In addition to this activity, however, there are other strong components of the Group which deal with the structure of pavements and other engineering activities such as traffic flow.

Respectfully submitted,

LAK Watt

L. A. K. Watt,
Dean of Graduate Studies.

LAKW:mvb
Att.

The curriculum vitae for the faculty members in the transport group were not properly updated in October, 1974. The following summary statistics cover the period 1970 - 1974.

Research Grants

Hutchinson	$ 150,000	(1970-74)
Haas	176,700	(1970-74)
Yagar	22,041	(1971-74)
Shortreed	61,859	(1970 & 1974)
Edens	3,000	(1974)
	$ 413,600	

Publications

Books	1
Refereed Papers in Journals	65
Papers in Published Proceedings	51
Technical Reports	31

The above clearly indicates that the grant income and publishing record of the group are considerably greater than the figures mentioned in the ACAP report. We feel, based on this data and outside recognition, that the cumulative accomplishments of the group are consistent with a first ranking on the consultants scale. Further, no other Canadian university has a group of comparable stature which surpasses the first criterion for a second ranking and few universities on this continent equal their record which, we believe should merit a first ranking.

The updated curriculum vita of each member of the transport group is attached.

Response of the University of Western Ontario to the Report of the Advisory Committee on Academic Planning with Respect to the Ph.D. Planning Assessment in Civil Engineering

March 12, 1975

This report has been prepared by a Committee of Senate charged with generating a response to the ACAP Consultants' report on doctoral studies in Civil Engineering.

In view of the recommendation that Western should subject its integrated program in Engineering Science to appraisal (Recommendation 6, page 5, COU report 11A Chemical Engineering) we should like to express our appreciation to the reviewers for their willingness to include the data from Western in their considerations and rankings. It was a source of considerable concern to us that a definitive document on Civil Engineering in this Province might totally exclude reference to significant activities proceeding at this University. These comments become more important because the present assessment recognises geotechnical engineering at Western which was entirely overlooked in the first report from the Civil Engineering Consultants.

At the same time we wish to draw to your attention one discrepancy in the estimate of the number of Faculty members involved in the operation of the structural and geotechnical groups. Attached please find an updated statement of faculty members.

Finally, there was some discussion about the parameters used in compiling the present report. Some members of the committee expressed concern about the rather detailed rankings undertaken by the writers of the report. It emerged from the discussion that the objective criteria used should reflect the quality of an academic department. There seemed to be some concern about whether adequate weight had been placed on the professional as opposed to academic qualities of the departments offering degrees.

The Civil Group submits the following list of currently active faculty members. There are 7 full-time professors and 4 research professors, in addition 3 individuals are primarily concerned with undergraduate teaching and extensive support is obtained from 2 individuals who fall outside the normal Civil Engineering Group, these are listed below:

Full-Time Professors	Research Professors
A.G. Davenport	N. Isyumov
M. Novak	D. Surry
R.M. Quigley	C.F. Lee
K.Y. Lo	J.H.L. Palmer
S.H. Abu-Sitta	
D. Harman	
M.P. Poucher	

Primarily Undergraduate	Outside Department
W.H. Peacock	T.E. Base
P. Rosati	P. Sullivan
W.H. Davis	

March 12, 1975

THE UNIVERSITY OF WINDSOR COMMENT ON APPENDIX I TO THE CIVIL ENGINEERING DOCTORAL PLANNING ASSESSMENT

The Civil Engineering Department at the University of Windsor originally was satisfied with the decision of COU to re-assess the Civil Engineering Doctoral programmes in Ontario. It assumed that such re-assessment would have a common basis for quality judgements made concerning the system. Consequently, it was seriously disappointed at the decision to disassociate Windsor and Western Ontario from the re-assessment process.

However, once this original decision was made, it would have been more satisfactory to Windsor to have been invited to discuss the matter of qualitative evaluation with the Sub-committee, a courtesy granted to the other six university representatives. Had this invitation been issued, Appendix I would have contained a correct statement of the quality of doctoral research in civil engineering at the University, rather than the present oversimplified statements.

Some Inconsistencies

The Sub-committee has been inconsistent in reporting grants. While they emphasized the operating grants received from NRC in all cases, they chose to ignore other grants in some instances while mentioning them in other instances.

The Sub-committee was equally inconsistent in the matter of publications. They either emphasized the refereed ones, or the refereed ones plus conference papers, or in some cases gave not a total number but only a range, say between 20 and 25! There are other inconsistencies!

Comments on the Structures and Water Resources Programmes at Windsor

The Sub-committee may have wished to know (or emphasize, since the data is in their files) the following information regarding Windsor's doctoral programmes:

We understand that the amount of research grants received by faculty was one of the major factors in deciding on the quality placement of each university. In the Water Resources programme, our average grant from NRC was quoted as $8,100. (Grants totalling $48,000 were also received from other sources and an additional $38,000 from NRC as equipment grant). We were classified as "Satisfactory" whereas another university with a lower grant average was placed in the "Excellent" category. Reference was also made to a university having an international reputation. This judgement must have been arrived at only through the private oral communication between the chairman of that Department and the Sub-committee.

It should be mentioned that the Water Resources Group at Windsor is also supported by two professors from the Mechanical Engineering Department and three professors from the Chemical Engineering Department. It is unfortunate that the Sub-committee did not elaborate on our publication record as was done for the other universities, nor comment on the high enrolment for Ph.D. students in the Water Resources in 1971-72 as was done in another university. Our specialty, for example in Water Pollution Control, was ignored, while it was emphasized for the other universities. An internationally known geomorphologist, A.E. Scheidegger, is joining the University in July, 1975 and will complement the Water Resources Group.

With regard to the Structures programme, our average NRC grant was quoted as $8,900. This average is based on seven faculty members, one of whom did not receive a grant and another who received only $3,000. The latter member has been most unfortunate in that for several years he was placed in a no man's land between the Civil Engineering and the Earth Science grants selection committees; therefore, his grant should be considered an anomaly. (It is less than one given to a starter!) If we deleted his grant contribution from the total received by the Structures group and divide the remaining total ($59,000) by six, the result is an average grant of approximately $10,000. This includes one faculty member who did not receive any grant! If we eliminate this faculty member our average grant would then be approximately $12,000. This procedure follows the precedent set by the Sub-committee in calculating average NRC grants for some universities in the Report.

It should also be mentioned that the work of some members in the Structures group has been recognized internationally and has influenced in some measure the codes of practice in Structural Engineering in Canada as well as in several other countries such as Britain and Japan. Furthermore, a text book co-authored by one member of the Structures group has been used extensively for the last eleven years in Canada, the United States (including M.I.T.) as well as in Britain, France, and Czechoslovakia; currently it is adopted by some 35 universities and colleges for use in the classroom. The Structures group is also supported by one professor from the Mechanical Engineering Department, two professors from the Engineering Materials Department and one professor from the Department of Geology.

Many of our Faculty members are on National and International technical and professional committees, contributing to the state of the arts in the profession and helping in the revisions of the Codes of Practice. Our research is both theoretical and experimental and almost all faculty members have a good industrial background. Many Commonwealth Scholars have chosen the University of Windsor for their studies; furthermore, many of our graduate students are NRC scholars. This is also a measure of the quality of our Ph.D. programmes.

All the foregoing could have been easily communicated to the Sub-committee if Windsor had been accorded the same privilege of a private interview as was given to each chairman of the other six universities on December 12. We hope that this brief transmission will rectify the description of our Ph.D. programmes contained in your current Report (Appendix I) and that it would lead to a quality judgement of something better than "Satisfactory".

DEPARTMENT OF CIVIL ENGINEERING
ELLIS HALL

Queen's University
Kingston, Canada
K7L 3N6
Tel. 613 547-6184

March 5th, 1975

Dr. M.A. Preston,
Executive Vice-Chairman,
A.C.A.P.,
O.C.G.S.,
130 St. George Street,
Suite 8039,
Toronto, Ontario, M5S 2T4

Dear Dr. Preston,

I write as Chairman of the Civil Discipline group.

The response of the group to the report of the Sub-committee of ACAP is as follows.

As a result of the ACAP decision not to include Civil Engineers on the sub-committee - a radical departure from all other engineering planning assessments - the Discipline Group cannot accept that the resulting report, prepared by predominantly non-professional consultants, can be used to plan the direction of Civil Engineering doctoral work in Ontario.

Accordingly, the Discipline Group reiterates its request that reputable Civil Engineering consultants be asked to calibrate the sub-committee report and the sundry university responses in order that the final ACAP report on Civil Engineering be a meaningful and valid one.

By calibration, the Discipline Group does not mean "informal, confidential, or ad hoc consultations", but a serious study of the validity of the judgments and subsequent recommendations appearing in the sub-committee report.

The original Civil consultants would be acceptable to the Discipline Group for such a task or a similarly qualified group acceptable to both ACAP and the Discipline Group.

Yours sincerely

Arthur Brebner

Dr. A. Brebner
Chairman,
Civil Discipline Group

AB:rm

APPENDIX 3

Procedure for Completing the Civil Engineering Planning Assessment

Procedure for Completing Civil Engineering Planning Assessment

ACAP has received the instruction from COU "to examine the available documentation and to reach its own judgments on the basis for a report, after soliciting assistance from the Discipline Group and the universities". In considering how to carry out this task, ACAP has come to the conclusion that work must be done in the first instance by a subcommittee consisting of three or four of its members.

It feels that this subcommittee will be more likely to reach sound judgments if it includes also a co-opted member who is an engineer, not from an Ontario university. This member would play exactly the same role as other members of the subcommittee, participating fully in all meetings including those with the Discipline Group. He would be chosen by ACAP.

The subcommittee will prepare a report to ACAP. This report will be circulated for comment to the universities and to the Discipline Group in much the same way as a consultants' report is. ACAP as a whole will then write a report which will have as appendices the report of this subcommittee, and the comments of the universities and of the Discipline Group.

OCGS has approved this procedure and OCGS recommends that COU also approve it.

21 May, 1974.

(This procedure was discussed and approved at the COU meetings of April 11, 1974 and June 7, 1974.)

APPENDIX 4

Comments from the Ontario Council on Graduate Studies

OCGS COMMENTS ON THE ACAP REPORT
ON CIVIL ENGINEERING

In retrospect, it is clear that the procedures agreed to by OCGS, CODE, and COU for the preparation of this new assessment report for Civil Engineering were fraught with particular difficulties and problems that were not anticipated. The comments of a number of universities reflect a lack of confidence particularly in regard to the quality ratings and the particular subdivisions used in the subcommittee report. CODE and its consultant, Dr. R.E. Legget, have also strongly criticized the subcommittee report (Appendix 1). In the future, if a report by ACAP consultants proves inadequate then COU and OCGS should weigh carefully the possible consequences of any alternative procedure that is contemplated.

In its latest report dated June 5th, 1975, CODE recommends that the ACAP assessment of doctoral work in civil engineering "be not accepted". CODE recommends also that "it would appear that there is no further need for the embargo on doctoral work in engineering, and CODE would suggest that COU so advise the Ministry." In reviewing these recommendations, OCGS has been sympathetic to the views expressed by civil engineering departments throughout the Province concerning the lack of civil engineering expertise among the members of the subcommittee that prepared the report on which ACAP now bases its recommendations. There are however, COU approved plans in existence for five other areas of Engineering and to suggest that the embargo on doctoral work in Engineering now be lifted without the completion of a similar plan for civil engineering appears unreasonable. The engineering departments covered by these other five plans are now being asked to honour the recommendations contained therein and to have civil engineering omitted from such planning would generate confusion and would seriously hinder the efforts of the universities in planning across the full spectrum of their engineering programmes. On the other hand, rejection of this new ACAP report as CODE recommends and the launching of another new effort aimed at preparing a further report would only result in further delays in the lifting of the embargo on engineering in general and would certainly cause a great deal of unhappiness on the part of the departments of civil engineering which would be asked once more to supply new data and information.

OCGS is of the opinion that the subcommittee deserves praise for the manner in which it tackled an extremely difficult task. The report of ACAP itself (April, 1975) OCGS believes, has gone a long way towards meeting the different objections raised by the universities and by CODE and in allaying many of the fears which were expressed. The recommendations contained in the ACAP report are moderate in tone and appear to be workable in practice. OCGS recommends that this ACAP report be accepted by COU subject to the following considerations:

1. The ACAP report of April,1975 does not emphasize the quality ratings which were used by the subcommittee. OCGS agrees that these should not be given any official recognition or sanction because serious doubts have been expressed about their credibility. As some of the universities and CODE point out they reflect the judgments of non-experts in civil engineering and the use of the particular descriptive terms in the subcommittee report further undermines the utility of the ratings.

2. In any assessment, recommendations for the development of new fields and for the expansion of existing ones should, of course, be consistent with universities' plans. This report has generated considerable discussion over the future of doctoral work in transportation in the province and Recommendation C40 suggests the discipline group arrange discussions amongst the concerned universities on this question. The outcome of these discussions should not be prejudged by suggesting that particular universities should or should not entertain the possibility of beginning doctoral work in this field. It is suggested therefore, that the reference to transportation in Recommendation C43 be deleted. Indeed, the wording of this particular Recommendation C43 on page 6 should be revised so that the phrase "either water resources or transportation," is replaced by "other than structures or geotechnical."

3. The comment of the University of Toronto on the recommendation that Doctor of Engineering Programmes be established is supported by OCGS and is reiterated here. The existing PhD programmes have been demonstrably successful in preparing students for careers in industry and no difficulty has been experienced in including adequate professional content in Ph.D. programmes. Recommendation C39 in the main ACAP report is considered unnecessary. There is acceptance of the point that there is generally a strong case to be made for the inclusion of a professional component in a civil engineering doctoral programme and when this is the case then the professional activities of the faculty members, for example as consultants and contract researchers, must be considered as a significant item in any successful assessment or appraisal.

4. The preparation of this new ACAP report on civil engineering has been a difficult and contentious task. In view of the different and often conflicting positions taken by some of the parties concerned, OCGS believes it is essential that all of the viewpoints be reflected in the final report. OCGS therefore recommends strongly that the above comments of OCGS be published along with the recent report from CODE dated June 5, 1975, and the report of Dr. R.F. Legget. Publication of Dr. Legget's report will require the approval of CODE: they should be urged most strongly to give their approval. Publishing in full all of the documents and reports connected with this study will present the most balanced picture possible. To omit any part of the documentation would present an incomplete and possibly distorted representation of the study.

July, 1975

APPENDIX 5

Comments from the Committee of Ontario Deans of Engineering 5-1 to 5-5

Legget Report 5-6 to 5-17

CODE

c/o Faculty of Applied
Science and Engineering,
University of Toronto,
TORONTO, Ontario. M5S 1A4

June 5, 1975.

Dr. R. L. McIntosh,
Chairman, OCGS,
c/o School of Graduate Studies,
Queen's University,
KINGSTON, Ontario.

Dear Dr. McIntosh:

Comments by CODE on ACAP Report on Civil Engineering Assessment

CODE at this time reaffirms its previously expressed reservations about this assessment (March 6 and March 18, copies attached). In framing this position, it sought the advice of Dr. R. F. Legget, former Director of the Division of Building Research, NRC, and a noted Canadian civil engineer. (His complete report is available on request). CODE recognizes, as stated in its March 18 letter to Dr. Preston, that it was involved in the determination of the assessment process, and it is only with hindsight that it perceives the process to have gone astray. It shares with the other parties involved the responsibility for the procedures themselves.

CODE considers that the subcommittee report contains poor judgments deriving from a lack of understanding of Civil Engineering and inadequate information. (See first paragraph p.2 of the March 18 letter.) The responses of the individual Universities, the discipline group, and CODE's earlier letters give sufficient justification for this harsh judgment. It is CODE's view that the cause of Civil Engineering education in Ontario will be harmed, not helped, (CODE understood system planning was intended to be a constructive activity!) by publication of the quality judgments contained in the sub-committee report. It appears that the only way now to prevent these from becoming enshrined in the literature of education in Ontario is simply to bury the report. The harm already done can probably not be repaired, but it should not be added to.

All the members of CODE do not necessarily agree with all of Dr. Legget's statements, but the following excerpts from his report are transmitted as valid comments on and criticisms of the assessment, that support the CODE position:

"(5) Terms of Reference.

It is now clear to me that the unfortunate misunderstanding that has developed between ACAP and the Civil Engineering Consultants is related to the stated Terms of Reference. If these had been drafted more carefully, and been more succinct (as is usual with Terms of Reference), difficulties might have been avoided."

"(6) The Consultants' Report.

I find this to be an excellent and well balanced review, giving exactly what ACAP asked for in their Terms of Reference."

"(7) University Comments.

I made my own review and assessment of the Consultants' Report before looking at the comments upon it in the several reports given to me. I was encouraged to find, in general, that my views were but little different from those of the Discipline Group, five of the Universities and, I believe, your own Committee apart only from some regret that the Consultants had not carried out the detailed assessment that is the main point at issue. Three of the eight Universities expressed varying degrees of disagreement and disappointment - Toronto, Waterloo, and McMaster. The opening and closing statements from the Discipline group express very well my own opinion of the Report."

"(8) ACAP Action.

The Report of ACAP to the Council of Ontario Universities dated 7 June 1974 (as revised) is the most curious document of all those I was asked to review. It is a slanted presentation. The use of such an expression as "penny packet enrolments" and the gratuitous words which conclude the statement on p. 31, as well as the reproduction of the exchange of letters with Dr. Meyerhof, sit strangely in a report from such academically distinguished men as the members of the ACAP Sub-Committee. The quotations on pages 30 and 31 from the Report of the Discipline Group give to the reader an erroneous idea of the generally commendatory remarks of this Group on the Consultants' Report."

"(9) Sub-Committee Report.

This is also a remarkable document quite apart from the fact that Dean Grenier, a distinguished engineer but not a civil engineer, was the only one of the five authors with engineering experience. Two thirds of the text consists of individual assessments arrived at on the basis of paper study, and talks with some interested parties but without any visits to the Universities reported upon." ... "Equally serious, in my view, is the evidence given by the Report as to the lack of understanding of what civil engineering is. On page 1-3, for example, it is suggested that in civil Engineering "the dichotomy is most extreme between research activity on the one hand and professional training on the other." It has been well said by a leading U.S. civil engineering educator and research worker (Professor R. B. Peck) that, in civil engineering, "the best fundamental research comes out of practical problems, especially troublesome ones." "

"(15) Criteria in this Study.

...And I really did think that the days of measuring research ability by the number of "refereed papers" and not by their character and quality had passed. To equate a half-column note in Nature (as in Chemistry or Physics) with, for example, a major professional civil engineering paper in the Proceedings of the American Society of Civil Engineers shows how misleading this criterion can be also."

Recommendation

CODE recommends that the ACAP assessment of Doctoral work in Civil Engineering be not accepted. It would appear that there is no further need for the embargo on Doctoral work in Engineering, and CODE would suggest that COU so advise the Ministry.

Sincerely yours,

B Etkin

B. Etkin
Chairman, CODE

BE/mwn
Encl.
c.c. Members of CODE
Civil Engineering Discipline Group

Report of Dr. R. F. Legget, commissioned by C.O.D.E.

27 May, 1975.

Dr. Bernard Etkin,
Chairman, C.O.D.E.,
c/o University of Toronto,
TORONTO, Ontario.

Dear Dr. Etkin,

Doctoral Programme in Civil Engineering at the Universities of Ontario.

In response to your request, which I appreciated, I now submit my comments upon the somewhat voluminous documentation with regard to the recent studies of doctoral programmes at the Universities of Ontario in civil engineering. In view of the extensive documentation arising from these studies, I had hoped to keep my own comments quite short. I shall be as brief as seems desirable but my study of the papers has raised so many questions in my mind that I would be failing you and the members of your Committee if I did not at least draw them to your attention. I say this since I now see so clearly with what a difficult situation you have to deal.

(2) Personal Interest.

It seems desirable to state, at the outset, that I had heard of the study now under review. I was asked to be one of the Consultants but was unable to accept the invitation. Since advising Dr. Preston of this by letter, some time in 1973, I have had no official communication of any sort about the study.

Dr. Meyerhof is a close personal friend. At one of our infrequent meetings, he told me that he was serving as a Consultant for the study but we had other things to talk about at the time and so no more was said between us about the matter, either then or later. I do not know any of the other Consultants or any of the members of the ACAP Sub-Committee.

In recent months, I have encountered evidences of the concern that exists about the reports in the departments of civil engineering at one or two Universities. When I expressed surprise at what I was told in one such encounter, I was loaned (privately) copies of the two Reports. I had, however, merely glanced through them when you asked me to make this review.

Finally, by way of personal explanation, I am happy to say that I know all the departments involved, except that at Windsor, and have the pleasure of knowing at least one member of the civil staff at all the Universities involved. I had the privilege of teaching in the Department of Civil Engineering at Queen's University from 1936 to 1938, and in that of the University of Toronto from 1938 to 1947 - now a long time ago, so long ago that I do not think that these happy experiences will influence my views on the matters under review.

3. Documents Studied.

I have read very carefully the following documents kindly provided to me by Dean George of Carleton University:

(a) The Consultants' Report of September 1973.

(b) The Report of the ACAP Sub-Committee of January 1975.

(c) Perspectives and Plans for Graduate Studies: 11 Engineering: A Chemical Engineering 1974 (the bound 229 page final report).

(d) Loose papers, presumably parts of the incomplete Civil Engineering Report corresponding to (c):

Appendix B: Discipline Group Response, Nov.14, 1973.

Appendix C: University Comments, Nov. 1973 (?)

Appendix D: Procedure of Planning Study and Terms of Reference, 1972-1973 (?)

Appendix E: Discipline Group Membership, n.d.

Appendix F: Role of ACAP and of Discipline Groups, April 6, 1973 (?)

Appendix G: Curriculum Vitarium of the Consultants, n.d.

Appendix H: C.O.D.E. Response, Dec.27, 1973 (?).

(e) Report to C.O.U. by ACAP of March 29, 1974, and revision of June 7, 1974.

(f) Appendix 2: University Comments and Discipline Group Comments, 19 March 1975 (?).

(g) A one page supplement to (b) dated April, 1975.

(h) ACAP Report to C.O.U. on Civil Engineering Doctoral Planning Assessment, April 1975.

(i) A second Reading of the Consultants' Report.

(j) A second Reading of the Report of the ACAP Sub-Committee.

By a strange coincidence, I had just finished reading the new book on Teaching at the Universities edited by E. F. Sheffield, McGill Queen's Press, when you telephoned me at the University of Minnesota. I find it relevant to the matter under review.

(4) A General Comment.

When I first heard of the exclusion of the results of the civil engineering study from the final report at ACAP, I was much concerned. Having now read the documents just listed, I am convinced that it is a very good thing that this development has taken place since it seems clear that the members of ACAP do not quite appreciate just what Civil Engineering is.

Civil Engineering is not a discipline; it is not a science; it is an art. It comes at the far end of the broad spectrum that is the profession of engineering with Chemical Engineering (probably) at the other end, as it grades into Applied Chemistry. Since no two projects in Civil Engineering practice are ever the same, education for this branch of the profession is closer in broad policy, in all probability, to the medical profession than to that for the pure sciences. I understand that ACAP has not yet given its attention to graduate training in medicine.

(5) Terms of Reference.

It is now clear to me that the unfortunate misunderstanding that has developed between ACAP and the Civil Engineering Consultants is related to the stated Terms of Reference. If these had been drafted more carefully, and been more succinct (as is usual with Terms of Reference), difficulties might have been avoided.

Item C2 requires the Consultants to "report on the adequacy of the present state of doctoral work in Civil Engineering" in the province in general and in each University, where applicable ..... (The first underlining is that of ACAP, the second is mine.)

Dr. Bernard Etkin.

Item C4, on the other hand, states that "it is permissible for consultants to recommend appraisals of individual programmes. This would arise if consultants were to suspect that a programme would be found to be wholly or in part below minimum acceptable standards .... it is recognized that this action would be infrequent." I can find no definition of the term "programme" so I would interpret it in the same way as have the consultants. Dr. Meyerhof and his colleagues did not find any such evidence as is suggested in C4 and reported accordingly. I agree with their interpretation of their duties, based on the papers before me.

I feel reasonably confident that any other civil engineer would reach the same conclusion especially since any individual assessment (such as ACAP apparently expected to get) would be, in effect, accreditation. Accreditation is something only now being accepted by the engineering profession. For it to be effective, it must be based upon precise and mutually agreed upon criteria. So important is this matter that I make further comment upon it later in this review.

(6) The Consultants' Report.

I find this to be an excellent and well balanced review, giving exactly what ACAP asked for in their Terms of Reference. Naturally one may question the emphasis on certain topics but my only major disagreement is with the statement (page A30) to the effect that "teacher staff will be of poor quality ...." if graduate studies are not associated with undergraduate teaching. Queen's University and the University of Toronto included Civil Engineering in their teaching programme for almost a century with no doctoral programmes, and only a very minor Master's programme in mid-century, but I venture to suggest that their staffs in this long period included some of the finest engineering teachers that this country has ever had.

But with all else I agree. I welcome the reference to part-time studies. I agree fully with the proposed shift in fields of interest, with some decrease in structural engineering. For doctoral work in particular I consider that there should be an increase in the proportion of geotechnical studies. I share the concern of the Consultants at the influence of BIUs, a concept to which I find difficulty in becoming accustomed. I agree that the unsatisfactory situation with regard to foreign students will probably be corrected gradually by changes in immigration regulations.

Dr. Bernard Etkin.

The factual information assembled by the Consultants is most useful but one fact thus brought to light alarms me - the indication that so large a proportion desire to, and actually are going into teaching after the procurement of the Ph.D. degree. It is my view, and that of many known to me, that nobody should be permitted to be a University teacher of Civil Engineering without having had several years of actual practical experience.

I refrain from any comment on what the Chemical Consultants so interestingly call 'the numbers game' but one has to consider the demand for, or need of doctoral graduates in Civil Engineering. This can only be done in consultation with the profession. The omission of any reference to this in the Report is very puzzling, especially since they give some weight to the views of students.

This must relate to the backgrounds of the Consultants selected. All are eminent men; let me please emphasize this as I go on to observe that not one has any relation with Ontario, its Universities or its professional engineering organization. This begins to explain the strange omission but it makes one wonder what rationale was involved in the selection of a Consultant, eminent though he is, from the United Kingdom where the practice of, and education for Civil Engineers differs to some extent from that in Canada, and specifically in Ontario.

In summary, however, I find the Report an excellent document and most useful planning guide.

(7) University Comments.

I made my own review and assessment of the Consultants' Report before looking at the comments upon it in the several reports given to me. I was encouraged to find, in general, that my views were but little different from those of the Discipline Group, five of the Universities and, I believe your own Committee apart only from some regret that the Consultants had not carried out the detailed assessment that is the main point at issue. Three of the eight Universities expressed varying degrees of disagreement and disappointment - Toronto, Waterloo, and McMaster. The opening and closing statements from the Discipline Group express very well my own opinion of the Report.

(8) ACAP Action.

The Report of ACAP to the Council of Ontario Universities dated 7 June 1974 (as revised) is the most curious document of all those I was asked to review. It is a slanted presentation. The use of such an expression as "penny packet enrolments" and the gratuitous words which conclude the statement on p.31, as well as the reproduction of the exchange of letters with Dr. Meyerhof sit strangely in a report from such academically distinguished men as the members of the ACAP Sub-Committee. The quotations on pages 30 and 31 from the Report of the Discipline Group give to the reader an erroneous idea of the generally commendatory remarks of this Group on the Consultants' Report.

I note that the Council did not accept the recommendation that a further study should be made by a discipline group, as a result of which the ACAP Sub-Committee decided that, "in the first instance (the further study should be made) by a special committee consisting of its engineering subcommittee increased to include an engineer from outside the Ontario university system."

If this means what I think it means, then academic planning for engineering graduate work in Ontario rests in the hands of non-engineers, eminent though the members undoubtedly are. I find this almost beyond belief. The Association of Professional Engineers of Ontario would be much interested in such an arrangement if they knew about it.

(9) Sub-Committee Report.

This is also a remarkable document quite apart from the fact that Dean Grenier, a distinguished engineer but not a civil engineer, was the only one of the five authors with engineering experience. Two thirds of the text consists of individual assessments arrived at on the basis of paper study, and talks with some interested parties but without any visits to the Universities reported upon.

What I find so very disturbing is that the eminent and experienced authors were so insensitive to the perfectly natural and healthy rivalry that exists between all Ontario Universities, in all faculties, as to attempt to rate individual programmes with the aid of a four unit scale. It baffles me how any group, no matter how distinguished, could determine that any programme was "comparable with the best in the world". But on this matter I need say no more; the Universities have themselves provided full and proper answer.

Equally serious, in my view, is the evidence given by the Report as to the lack of understanding of what civil engineering is. On page 1-3, for example, it is suggested that in civil

Engineering "the dichotomy is most extreme between research activity on the one hand and professional training on the other." It has been well said by a leading U.S. civil engineering educator and research worker (Professor R. B. Peck) that, in civil engineering, "the best fundamental research comes out of practical problems, especially troublesome ones."

Three pages later we find this statement: "the decrease in doctoral enrolment is delaying some research projects whose immediate utility is testified to by the provision of ample grants and contracts." This made me wonder if I was reading a Report dealing with post-graduate education or the operation of a research establishment.

It is therefore refreshing to find that the Council of Ontario Universities, in its instructions to ACAP (page 1-10) recommends a substantial effort "to discuss with employers steps to be taken jointly to overcome the shortage of Canadian students." This ACAP failed to do.

(10) University Comments.

I need only indicate my general agreement with the comments from the Universities generally. I would especially commend the masterly statement from the University of Toronto, only regretting that so much time and effort had to be devoted to the preparation of this document. The reference in this to Building Codes is a most useful reminder of the essential inter-locking of professional practice and research work, the continuing revision of Building Codes being a fruitful generator of useful research projects, as I know well from my own work in Building Research.

COMMENTARY

(11) The Nature of a University.

Throughout my adult life, it has always been my understanding that a University, as a "company of scholars" (to use again the old phrase) was essentially a teaching institution of higher learning, teaching being its prime responsibility all else, including research, being ancillary. I find no evidence that this view influences ACAP in its important work but rather the implied suggestion that the prosecution of research is the principal purpose of a University. On p.1-12 of the ACAP Report it is stated that the ratings so lamentably adopted "do not have any necessary relationship to undergraduate programmes." One may well ask - "Why Not?".

(12) The Nature of Engineering.

It is now generally admitted that professional education does have a real place in the modern University. And engineering is a profession, utilising fully the application of all relevant sciences. This is shown by the fact that it is still possible (I believe) to enter the profession of engineering in Canada without going to a University, but rather by writing professionally-set rigid examinations. In Great Britain this way of entering the profession is still not uncommon. Accordingly, it is clear to me that planning for engineering graduate training in Ontario needs an approach quite different from that adopted for the pure sciences. To find that it is being done at present by a committee that does not include one engineer in its membership, academically eminent though the members undoubtedly are, is still almost incredible to me.

(13) Professional Interest.

This overall view is confirmed for Civil Engineering by the fact that all major national civil engineering organizations known to me take a lively interest in all aspects of engineering education. The American Society of Civil Engineers, for example, had a major meeting last year at Ohio State University, devoting several days to this one subject alone, as a part of their continuing activity in this field. In Great Britain, the Institution of Civil Engineers is now awaiting the final version of the report of a special top-level committee (the 'Chivers Committee') which will provide an in-depth study of the whole field of civil engineering education in Great Britain. In Canada, the Canadian Council of Professional Engineers (representing the more than 60,000 engineers of Canada) is so vitally concerned with engineering education that it is now responsible for a nation-wide accreditation system for undergraduate engineering education. Yet neither the Council, nor the Association of Professional Engineers of Ontario were consulted about the study now under review. Again, one may ask - "Why Not?".

Dr. Bernard Etkin.

(14) Accreditation.

This has now been accepted by all Universities in North America (although still regarded by some as a 'necessary evil'). To date it is in operation for undergraduate programmes only, although in the United States it does now cover the five-year Master's programmes now in operation at a few Universities. In both Countries it is, however, the responsibility of the professional engineering organizations - in the United States, the Engineers' Council for Professional Development, and in Canada (as noted) the Canadian Council of Professional Engineers. As you and your colleagues know all too well, reluctant acceptance of accreditation in Canada came only after several years had been spent in the difficult task of gaining agreement upon precise and mutually acceptable criteria, upon which assessments of individual programmes could be made, criteria which even now are under critical review for further refinement.

(15) Criteria in this Study.

The criteria used by ACAP for their assessments can be deduced only from their individual statements. They appear to include the total of NRC grants and the number of "refereed papers". As to the first, having for many years watched NRC Grant Committees at work (as one of the advisers), I know how misleading any such use of totals can be. The good engineer research worker will often get most of his funds from the industry, the NRC grant being merely a 'topping-off' for some special purpose or instrument, making the NRC sum useless as an index in itself. And I really did think that the days of measuring research ability by the number of "refereed papers" and not by their character and quality had passed. To equate a half-column note in Nature (as in Chemistry or Physics) with, for example, a major professional civil engineering paper in the Proceedings of the American Society of Civil Engineers shows how misleading this criterion can be also.

On the other hand, I have not found a single reference to the teaching load of staff in any of the documents under review. Surely this is where assessment should start? I have had time to make only one or two quick checks on this matter but these confirm what I suspected - namely that 'weaknesses' in research productivity found by ACAP indicated excellence of teaching and an unusually heavy teaching load.

(16) Professional Experience.

The members of the ACAP Sub-Committee appear to equate professional experience with consulting work.

Dr. Bernard Etkin.

Specialist consulting by staff members, under well recognized restrictions (e.g. always subsidiary to teaching, never competing with regular consultants, and always with the element of research in it) has long been a hallmark of the active civil engineering department, difficult though it is (in some cases) to administer. This is not, however, the practical experience upon which good teaching depends. This comes only from full-time employment on civil engineering design and construction for some years after graduation. This is stated by the Mechanical Engineering Consultants and is implicit in the Report of the Civil Engineering Consultants. It is upon such experience, and not upon laboratory research, no matter how good, that good teaching and, in fact, ability in civil engineering research, ultimately depend.

It is such experience that gives that 'mastery of the subject' which is so clearly at the top of the list of 'attributes of the good teacher' with which Teaching at the Universities so helpfully concludes. I do not have my copy of this most excellent book at my side to check, but I am almost certain that ability in research does not appear in the long list at all, nor can I recall more than the occasional reference to research in the interesting text. All this is in strange contrast with the documents under review, and especially with incidental references to staff.

(17) Language Requirements.

Although I can understand the relaxation in the language requirements for the Ph.D. degree, in view of the wide availability of translation services, I shall never understand why all Canadians who are privileged to take the highest academic degree in the land are not required to be fluent in the two official languages of Canada. There is no reference to this in any of the documents studied.

(18) Future Demand.

I am not at all surprised at the decrease in numbers of candidates for a doctoral degree in civil engineering nor does this fact cause me concern. In my view, the demand for such training will come, during the foreseeable future, not from the profession or construction industry but from the personal desires of unusually gifted students who have the calling to continued study. No 'numbers game' can be attached to such a demand.

Dr. Bernard Etkin.

Civil engineering in Canada faces so challenging a future, looking ahead merely to the end of the century, that the demand will be for well-trained graduates at the bachelor's or master's level, who can 'get on with the job' of designing and constructing the massive extension of Canada's physical plant that can be seen, even now, to be in prospect, with only a few specialists such as those gifted younger people who take the Ph.D. degree. What will be needed, in post-graduate education, in my view, is a vast increase in part-time facilities and in what I may call 're-training' for those in practice who wish to keep themselves up to date with professional technical development, such as is so common a practice in the medical profession. I am therefore most pleased to see that the ACAP Sub-Committee supports the Consultants' suggestion in this field.

A SUGGESTION

(19) The harm done by the controversy herein so briefly reviewed, and especially by the 'ratings' of the ACAP Sub-Committee, can not be undone but in the course of time the emotional reactions that have been so naturally generated will happily be forgotten.

May I therefore venture to suggest that the recommendations of ACAP and its Report of April 1975, if and when accepted by the Council of Ontario Universities, be accepted pro tempore, despite their background, but with the definite understanding that the 'questionable' rating does not mean, to you, 'inadequate' but rather requiring further study; that after a discreet interval (perhaps two or three years) an entirely fresh approach to the whole subject of post-graduate training in engineering in Ontario be made, by engineers, quite separately from any such study for the pure sciences, and in the closest consultation with the Association of Professional Engineers of Ontario; and this - if I may go so far - that the matter of part-time graduate work, and re-training in general, be given special attention as soon as may be possible.

Dr. Bernard Etkin.

l'ENVOI

(20) As I prepare to return to Dean George of Carleton University the 'papers' which he so kindly furnished to me, and as I look at the large pile of paper involved already in this study for a total enrolment of about 100 and less than a quarter of this number graduating each year, I am reminded of one of the first lessons that every young civil engineer has to learn on the job - that Time is Money.

May I, therefore, beg leave, with great respect, to associate myself with you and the members of your Committee wholeheartedly in your most moderate statement at the end of your Report of 27 December 1973, namely: "CODE has yet to be convinced that the extensive funds and efforts devoted to the studies would not have been better spent in direct support of existing Ph.D. programs in engineering."

Yours faithfully,

(Original signed by)

ROBERT LEGGET

ADVISORY COMMITTEE ON ACADEMIC PLANNING

ONTARIO COUNCIL ON GRADUATE STUDIES

REPORT TO THE COUNCIL OF ONTARIO UNIVERSITIES
ON
ENGINEERING DOCTORAL PLANNING ASSESSMENTS

JUNE 7, 1974

TABLE OF CONTENTS

		Page
I	Recommendations	1
II	Background and Procedure	8
III	General Recommendations	13
IV	University Recommendations	20
	- University of Western Ontario	20
	- University of Windsor	22
	- University of Guelph	24
V	Chemical Engineering	25
VI	Civil Engineering	28
VII	Electrical Engineering	36
VIII	Mechanical Engineering	38
IX	Metallurgical and Materials Engineering	41
X	Mining Engineering	44
XI	Industrial Engineering and Systems Design	45

For each planning assessment (Chemical, Civil, Electrical, Mechanical, Metallurgical, and Industrial) there are appended:

Appendix A - Consultants' Report

Appendix B - Discipline Group Response

Appendix C - University Comments

Appendix D - Procedure of Planning Study and Terms of Reference

Appendix E - Discipline Group Membership

Appendix F - Roles of ACAP and of Discipline Groups

Appendix G - Curricula Vitarum of the Consultants

Appendix H - CODE Response

I. RECOMMENDATIONS

General Recommendations

C1

It is recommended that COU abandon the quota of 450 doctoral student enrolment in 1974-75, and plan on roughly the present enrolment for the next five years, assuming greater interest by Canadian students in engineering graduate work. If this interest does not materialize, the enrolment will undoubtedly drop. In any case, it is recommended that CODE be asked to report annually to COU on enrolment and employment opportunities.

C2

It is recommended that steps be taken to inform potential candidates of the value of a PhD in many phases of government and industry, not only in research and development. The universities, individually and collectively, through agencies such as CODE, should discuss with the industrial and governmental employers steps to be taken jointly in order to overcome the shortage of Canadian students.

C3

It is recommended that the universities maintain the situation where Canadians and landed immigrants constitute at least 70% of the doctoral enrolment in any programme, at any one time, even though the number of landed immigrants may decrease.

C4

It is recommended that the universities, the provincial government, and granting agencies consider the remarks of the consultants and examine the extent to which the limit to student income deters Canadians from entering graduate work. Means of supplementing the income of professionally experienced students should be examined; increased contacts between faculty and industry could lead to increased industrial support.

C5

It is recommended that each Discipline Group monitor annually the admissions experience of each programme (post facto) and report on the quality of the admitted students to ACAP for transmission to COU.

C6

It is recommended that all doctoral thesis examining committees should have an examiner external to the university.

C7

It is recommended that each Discipline Group and CODE develop proposals for making information on graduate work in all Ontario universities readily available to the engineering students, in some collective way and inform ACAP of the action taken. Each Discipline Group should report annually on the university last attended by the graduate students in each department.

C8

It is recommended that at the present any part-time or non-resident doctoral work should be by individual arrangement and that experimentation in this type of programme be encouraged. It is also recommended that the research topic of the student accepted on a part-time basis be in a field in which the professors in the department have expertise. It is recommended that OCGS examine existing university guidelines in this area.

C9

It is recommended that the universities report to ACAP (for OCGS) each year on the time taken by each graduating student to complete his doctoral studies.

University Recommendations

C10

It is recommended that the University of Western Ontario continue its examination of its PhD programme in engineering science, and put forward the resulting programme for appraisal, in particular delineating carefully the areas of research in which it feels it appropriate to accept students. In case a favourable appraisal is not obtained by October, 1976, admission of new students should then be suspended.

C11

It is recommended that the University of Windsor continue the reorganization of its doctoral work in engineering and submit all programmes (presumably these will be the three divisional programmes which are replacing the departmental programmes), for appraisal when the new system has been in operation sufficiently long to permit a valid appraisal. Enrolment of new students should cease after October, 1977, if a favourable appraisal has not been obtained by that date.

C12

It is recommended that the involvement of the School of Engineering in the hydrology doctoral programme at the University of Guelph continue and that the University begin doctoral work in agricultural engineering at a time in accordance with the University's plans, subject to normal appraisal procedures.

Chemical Engineering

C13

It is recommended that the departments take note of the consultants' recommendation 10 to group research activities in well defined areas so as to establish or reinforce teams, thus providing a more stimulating environment for students.

C14

It is recommended that McMaster University continue its doctoral work in chemical engineering according to its plans.

C15

It is recommended that the University of Ottawa continue its doctoral programme in chemical engineering according to its plans.

C16

It is recommended that Queen's University reevaluate its doctoral programme in chemical engineering in the light of comments made by the consultants concerning research activity of the faculty, the grouping of research areas, the awareness of new trends in the discipline, and the mobility of its bachelor's graduates, and submit the programme for appraisal at the time that the University considers appropriate. If a favourable appraisal has not been received by October, 1976, enrolment of new students should be suspended at that date.

C17

It is recommended that the University of Toronto continue its doctoral programme in chemical engineering according to its plans, paying particular attention to Recommendation C7 regarding mobility of its graduates and to Recommendation C13 concerning grouping of research areas. It is recommended that the University of Toronto report to COU through ACAP by June, 1975, on action taken in regard to this Recommendation.

C18

It is recommended that the University of Waterloo continue its doctoral programme in chemical engineering according to its plans.

Civil Engineering

C19

It is recommended that COU recommend the continuance of the embargo on the funding of any new programmes in civil engineering until COU has accepted a Discipline Group report dealing adequately with the future role of each department in respect to the different fields of doctoral research, paying particular attention to the relative strengths and weaknesses of each department and the change in emphasis on fields recommended by the consultants. The report should be submitted to ACAP by December 31, 1974.

Electrical Engineering

C20

It is recommended that the Discipline Group annually identify those areas of electrical engineering which they consider relevant to the present and future needs of Canada and make their findings available to the granting agencies and various associations of industry in order to stimulate a continuing dialogue with industry.

C21

It is recommended that Carleton University continue its doctoral work in electrical engineering according to its plans.

C22

It is recommended that McMaster University continue its doctoral work in electrical engineering according to its plans.

C23

It is recommended that the University of Ottawa continue to offer a doctoral programme in electrical engineering restricted to theses in digital communication systems and large-scale systems. This limited programme is to be appraised as soon as possible. Enrolment of new students should cease as of December, 1975, if a favourable appraisal has not been obtained.

C24

It is recommended that Queen's University continue its programme in electrical engineering concentrating in the communications and systems fields, with occasionally a student in cognate areas of electronics and energy processing. Any proposed substantial developments in these latter two fields would be submitted for appraisal. It is also recommended that the department maintain enrolment at its present level.

C25

It is recommended that the University of Toronto continue its doctoral work in electrical engineering according to its plans.

C26

It is recommended that the University of Waterloo continue its doctoral work in electrical engineering according to its plans.

Mechanical Engineering

C27

It is recommended that Carleton, McMaster and Queen's Universities continue their doctoral programmes in mechanical engineering and during the coming year give careful consideration to the feasibility of a stronger development of foci of interest in the special areas of strengths suggested by the consultants. The Universities are requested to report to COU and OCGS, through ACAP, during the fall of 1975, on the results of these considerations.

C28

It is recommended that, if the University of Ottawa wishes to reactivate a doctoral programme in mechanical engineering, it give careful consideration to allowing some further maturing of the department before applying for appraisal.

C29

It is recommended that the University of Toronto continue its doctoral programmes in mechanical engineering in its Department of Mechanical Engineering and the Department of Aerospace Studies and Engineering. ACAP suggests that the University consider the consultants' recommendation of a greater concentration of research activities of the Department of Mechanical Engineering on major problems of national concern. It is recommended that the University inform COU and OCGS through ACAP, during the fall of 1975, of any decision taken.

C30

It is recommended that the University of Waterloo continue its doctoral programme in mechanical engineering. ACAP suggests that the University consider the consultants' recommendation of a greater concentration of research activities on major problems of national concern. It is recommended that the University inform COU and OCGS through ACAP, during the fall of 1975, of any decision taken.

Metallurgical and Materials Engineering

C31

It is recommended that the universities take note of the consultants' recommendations 1, 2, 3b and 3c, dealing with the weakness in certain fields of study in the province and that the Discipline Group report to ACAP on any action taken in consequence of these recommendations.

C32

It is recommended that McMaster University continue its doctoral programmes in material science and extractive metallurgy, and noting the strength attributed to these programmes by the consultants, make a report in the fall of 1975 on the following suggestions for improvement:

a. recruitment of students with physics and chemistry backgrounds

b. strengthening of the extractive metallurgy faculty

c. collaboration with Toronto

C33

It is recommended that Queen's University continue its doctoral work in physical metallurgy and discontinue the doctoral programme in extractive metallurgy and mineral engineering as it now exists and replace it by an enlarged programme involving professors in other departments as suggested in the consultants' report. This new programme should be appraised and this should be completed by December 31, 1976. If Queen's does not wish to enlarge its programme in extractive metallurgy and mineral engineering, the present programme should be put forward immediately for appraisal, ceasing to enrol new students by June 30, 1975, if a favourable appraisal is not obtained.

C34

It is recommended that the University of Toronto continue its doctoral programmes in its Department of Metallurgy and Materials Science. It is suggested that Toronto give careful consideration to the consultants' recommendations concerning broadening the programmes and it is recommended that the University report to COU through ACAP by September, 1975, on any progress made in this direction.

C35

It is recommended that the University of Waterloo continue its engineering doctoral work in extractive and process metallurgy and in metallurgical engineering and materials science according to its plans.

Mining Engineering

C36

It is recommended that Queen's University continue its doctoral work in mining engineering in accordance with its plans.

Industrial Engineering and Systems Design

C37

It is recommended that the University of Toronto continue its doctoral work in human factors engineering, management information systems and operations research.

C38

It is recommended that the University of Waterloo continue its doctoral programme in systems design.

II. BACKGROUND AND PROCEDURE

In June, 1968, the Committee of Presidents of the Universities of Ontario, after a meeting with the chairman of the Committee on University Affairs, decided that a comprehensive review of engineering education in Ontario should be undertaken. The Committee of Ontario Deans of Engineering (CODE) was requested to draw up plans for such a study, and this proposal was approved by the Committee of Presidents on November 15, 1968. The objective was to create a master plan which could be used as a guide for rational growth of engineering education during the 1970's. Such a plan should endeavour to provide for the highest attainable quality, the best use of resources, opportunity for innovation, and maximum freedom of choice for students.

This study culminated in the report Ring of Iron prepared by a commission chaired by Philip Lapp.

The report was received by the Committee of Presidents in January, 1971. A process of review of the report's recommendations was established, CODE prepared a brief based on statements of views submitted by each university concerned and by each Faculty of Engineering. Briefs were prepared also by the Ontario Council on Graduate Studies (OCGS) and the Association of Professional Engineers of Ontario. On October 5, 1971, the Council of Ontario Universities (COU) considered Ring of Iron and the briefs and prepared a statement of recommendations to the universities and to CUA.

COU accepted a number of the Lapp recommendations without change, others with amendments and rejected some. Broadly speaking, the recommendations to do with undergraduate matters were accepted or modified slightly. The graduate area of the report was more controversial, but here also some recommendations were accepted. The most significant of the recommendations concerning graduate study, as approved by COU, are:

> "The criteria of acceptability of graduate degrees in engineering should be recast in order that a thesis based on design or systems synthesis may be suitably assessed. This could involve the establishment of a new degree at the doctorate level."

> "Both universities and industries should recognize joint appointments as part of the career structure of their senior staff; these appointments should be increased as far as possible..... By this we understand a system of part-time appointments."

> "Over the next two years the estimated graduate enrolment of 2,000 full-time equivalent students for 1970-71 be reduced by 17%, after which graduate enrolment should be limited to a number equal to the previous year's bachelor graduations. The enrolment figure applies to the engineering departments as identified in Ring of Iron".

> "The recommendation that the number of PhD students enrolled be reduced to 450 per year is fully supported by all groups including COU. However, COU, along with CODE and OCGS, recommends that the figure of 450 be the target for 1974-75, rather than for 1973-74, for reasons related to avoiding large fluctuations in enrolment as explained in the OCGS critique."
>
> "The Lapp report recommends specific numbers of PhD enrollees for each of the universities including discontinuance of the PhD enrolment in certain universities. COU feels that the reasons for the numbers chosen or for the elimination of certain doctorate programmes are not fully documented in the Lapp report. COU also agrees with CODE and OCGS that attention must be given to the numbers of doctorate enrollees by discipline as well as by university. For these reasons COU recommends that for the year 1972-73 doctorate enrolment be reduced in each university below the projected figure for 1971-72 by a pro rata percentage in order to provide 612 doctoral candidates (the number required to achieve the target of 450 in 1974-75). Preliminary acceptance of the OCGS method for reducing PhD enrolment (by limiting new PhD enrolments to achieve a total system number of 450 by 1974-75) is based on plans for discipline planning assessments respecting PhD programs to be initiated immediately and completed as rapidly as possible. Such assessments will be carried out by ACAP in cooperation with CODE; they are to incorporate capability, demand and quality correlates, and are to be used to provide specific recommendations on changes for the total PhD enrolment, and for the division of the enrolment amongst universities and amongst disciplines. The assessments are to incorporate a review of the effects of the pro rata reductions in 1972-73, and to recommend a mechanism for continuing review of PhD enrolments."

On receipt of this instruction from COU, ACAP and CODE established a liaison committee (Ayers, Dillon, Ham, Johnson, Shemilt, McIntosh, Preston) which drafted procedures for the assessments. It may be noted that the committee considered a model in which the assessments were based, not on the five traditional departments found in engineering faculties, but rather on interdepartmental areas of research; the practical difficulties of conducting the assessments led the committee to recommend the five-fold subdivision actually used.

The procedure developed in this way was approved by ACAP on March 17, 1972, and by COU on April 7. The procedure (except for minor data amendments) is that in Appendix D to this report. In writing to indicate its approval CODE expressed their understanding that two objectives would be met:

> "1. To provide a rational basis for doctoral work in engineering and for confirming or modifying the limitation on enrolment suggested by Lapp.
>
> 2. To conduct a really effective assessment of the quality of our current doctoral programmes."

CODE went on to emphasize the need of adequate resources to obtain the best consultants.

In order to begin the planning assessments, the ACAP/CODE liasion committee called a meeting of members of the five Discipline Groups (Chemical, Civil, Electrical, Mechanical, and Metallurgical Engineering). This meeting on April 12, 1972, indicated a good deal of faculty resistance to the conduct of the planning assessments and uneasiness about some perceptions of some aspects of the approved procedures. This resulted in a delay in mounting the assessment. CODE suggested a Coordinating Task Force, consisting of two members of CODE, the chairman of each Discipline Group, and a member of ACAP could review the procedures. ACAP advised COU to agree to this request and the COU executive did so on June 9, 1972. This Task Force held meetings on June 29, July 27, September 1, September 25, November 29, 1972 and March 19, 1973. It suggested two slight additions to the procedures as approved earlier by COU. These were approved by COU on September 25, 1972. The Task Force also produced a document clarifying some aspects of the procedure in detail, and a statement of some educational philosophies concerning doctoral study. These documents are referred to in the terms of reference of the consultants. The Task Force also advised ACAP (and so did universities) on how to take into account for planning purposes those doctoral programmes in Faculties of Engineering which did not fall obviously into the fields covered by one of the five consulting teams. It was eventually decided that:

a) both the metallurgy and the mechanical engineering consultants would be asked to consider the metallurgical work within the Department of Mechanical Engineering at Waterloo

b) no advice from external consultants would be sought on the doctoral programme in mining engineering at Queen's

c) a small-scale "planning assessment" involving two consultants would be carried out in industrial engineering and systems design

d) in view of the fact that all current doctoral students at Guelph are in hydrology and that the field of agricultural engineering is also proposed, the civil engineering consultants would be asked to consider the Guelph doctoral work, with the understanding that if they so wished ACAP would facilitate a consultation for them with someone in a department of agricultural engineering

e) the mechanical engineering consultants be asked to consider the doctoral work at the University of Toronto Institute of Aerospace Studies and in aeronautical engineering at Carleton, with the request that they consult also with another of the ACAP consultants (on the Electrical Engineering team) who had expertise in some of the UTIAS work outside mechanical engineering and also with an aerospace specialist.

f) advice on the future plans of the Department of Management Science at Waterloo would be sought from the consultants in the planning assessment in Administration, Business and Management Science, with a comment also provided by the consultants on industrial engineering.

g) no special arrangements were needed in connection with biomedical engineering at Toronto since the corresponding institute has no graduate programme of its own, and the future doctoral plans are covered in the statements from each of the associated departments.

Item f) will be dealt with in a later report. The remainder are covered in this report. The mechanical engineering consultants informed ACAP that they did not require the assistance suggested in item e).

In October, 1972, CODE proposed that a study be carried out, under the aegis of the newly established Canadian Engineering Manpower Council, and with financial support from a number of agencies, in order to make recommendations about "supply and demand" for engineering doctorates. This would be expected to be of great value to the planning assessments. ACAP agreed to this suggestion, provided funds towards the costs, and incorporated reference to the study into the instructions for the consultants. In the event, the study proved rather disappointing; it is discussed later in this report.

As a result of suggestions from the Discipline Groups and after receiving comments from the Coordinating Task Force and from CODE, ACAP agreed on consultants at its meetings of September 7-8, October 13 and December 18, 1972. The consultants who finally acted were:

Chemical Engineering:	Dean P. Grenier of Université Laval, Dean W.R. Marshall of the University of Wisconsin, Professor L. Yaffe of McGill University
Civil Engineering:	Professor W.W. Eckenfelder of Vanderbilt University, Mr. B.V. Martin of Alan M. Voorhees and Associates Ltd., Professor G.G. Meyerhof of Nova Scotia Technical College, Dr. J.L. Boulet of Hydro-Quebec
Electrical Engineering:	Professor A.D. Moore of the University of British Columbia, Professor M.E. Van Valkenberg of Princeton University, Dr. M.P. Bachynski of RCA Research Laboratories

Mechanical Engineering: Professor H.W. Emmons of Harvard University, Dean G. Ford of the University of Alberta, Dr. R.D. Hiscocks of the National Research Council of Canada, Professor S.G. Mason of McGill University

Metallurgical Engineering: Professor J.J. Jonas of McGill University, Professor T.B. King of the Massachusetts Institute of Technology, Professor W.S. Owen of Northwestern University and M.I.T., Dr. W.B. Lewis of Atomic Energy of Canada Ltd.

Brief curricula vitarum appear in Appendix G. In each case, the last named person played the role of a senior Canadian from outside the discipline.

The consultants held their first meetings at various dates in April and May, 1973,and in each case met with the appropriate Discipline Group, arranged the schedule of visits, discussed their character and had general discussion with the Discipline Group about the task before them. The visits took place in the two or three months following these meetings.

The consultant teams each submitted a draft report in September, which was the subject of oral discussion with the Discipline Group at a meeting within a few days of the receipt of the draft. Each consultant team then submitted its report. These reports were sent for comments to the universities, to the Discipline Groups and to CODE, each of which sent comments to ACAP at various dates in November, December, and January.

A subcommittee of ACAP began consideration of the report to COU, before all the comments were in hand and continued its work through March, 1974, reporting regularly to ACAP and receiving instructions. Early in its meetings the committee identified some points on which further information and reactions were required. In particular, the need for fuller advice from the consultants was felt in the cases of civil and mechanical engineering. Such further advice was sought, with results discussed in the relevant sections of this report. ACAP also thought some further information would be helpful in connection with three of the universities and arranged meetings with officials of these universities and members of ACAP.

This report is based on the consultants' reports, the data collected for the study, the universities' comments and supplementary material from some of them, the Discipline Groups' responses, and the other documentation referred to in the procedures and terms of reference. The report sets out recommendations for COU on doctoral work in engineering in Ontario for the next few years.

As is required, ACAP presents this report directly to COU. It has also been transmitted for information to OCGS, CODE, and the Discipline Groups.

III. GENERAL RECOMMENDATIONS

This section of the ACAP report contains recommendations that are of general concern to all of engineering. Some of these recommendations have been mentioned consistently in all the reports while others, although found in only one report, are applicable to all doctoral programmes.

Enrolment and Manpower Forecasts

In the summer of 1973, the Canadian Engineering Manpower Council released its report entitled Supply and Demand for Engineering Doctorates in Canada. This report was partly financed by ACAP and was given to all the consultant teams prior to their writing of their reports. It generally states that the supply of engineers in the next five years will exceed the demand.

A summary of the comments made by the engineering consultants concerning this report shows that they all independently disagree with the projections made in the CEMC report. They believe there has been no overproduction of PhDs to date and, in fact, there appears to be a shortage of metallurgical PhDs. Each team believes that the need for engineers will not decline, as predicted by CEMC but that the overall demand will continue and in actual fact, all but the civil engineering consultants believe it will increase.

ACAP had originally intended to publish a critique of the CEMC report. However, CODE in its repsonse to the engineering reports, Appendix H, has included a statement on this report covering all the points ACAP wished to make. ACAP's critique will not be reproduced, but we feel that the CEMC report is not an adequate basis for manpower planning in engineering. Since all the consultants agree that supply will not exceed demand but perhaps rather the reverse, the question of supply of qualified students must be studied. The main problem will be attracting Canadians into engineering graduate work. In 1972-73, of the 518 F.T. engineering PhDs, 28.6% were Canadian, 53.3% were landed immigrants and the remaining 18.1% were on student visas.

Changes in the immigration regulations make it harder to become a landed immigrant. Since one can no longer apply for landed immigrant status while in Canada, those that come on student visas will presumably return to their homelands. Coupled with this is another new regulation that a teaching assistantship is no longer classified as a job, thus making it harder to obtain landed immigrant status. Consequently, ACAP feels that the percentage of landed immigrants in graduate work will drop while the number of students visas will increase. Financial support for people on student visas is scarce. There are very few scholarships or bursaries open to them but in engineering they may be supported from contract funds. In any case, there will be funds for only a few. Although Canada has a role to play in providing advanced technical education for the underpriviledged countries of the world, this should be kept to a reasonable level and should not exceed 30% of engineering doctoral enrolments.

CODE, on page H-9 of its response, states that "unless the proportion of Canadian bachelor degree graduates choosing to undertake PhD studies changes drastically, the numbers of qualified applicants coming forward will certainly decline". There are suggestions that student stipends be increased. We remain unconvinced that stipends need be any higher in engineering than in any other field, but there is one exception and this is that people with substantial professional experience returning to graduate study should be supported at a higher level.

ACAP is inclined to agree with the University of Waterloo's comment, page 6-29 in its response to the chemical engineering report, that the best way of attracting Canadian students is a "change in the general atmosphere surrounding doctoral work in engineering in this country and to convince the brightest young Canadian students that there are challenging opportunities for advanced work in Canadian industry". Increased dialogue with industry as well as up-to-date information on jobs available would make the employment picture brighter and more alluring to prospective Canadian graduate students especially if the number of industrial scholarships were increased and more interaction were seen to be taking place between industry and university.

This dialogue with industry is needed to ensure that more Canadians continue in graduate work. If industry indeed has a place for the master's or doctorate in engineering, more must be done to encourage good students to stay in university instead of taking a job after the bachelor's degree. Industry in its hiring policies can encourage this.

The chemical engineering consultants recommend that the universities should endeavour to develop entrepreneurship in students. They feel "this is a quality so badly needed at present in Canada".

It does not seem as though Ontario will overproduce engineering PhDs in the next five years. The question is rather whether there will be enough qualified students. In view of this possible shortage, the following recommendations are made by ACAP.

Recommendation C1

> It is recommended that COU abandon the quota of 450 doctoral student enrolment in 1974-75, and plan on roughly the present enrolment for the next five years, assuming greater interest by Canadian students in engineering graduate work. If this interest does not materialize, the enrolment will undoubtedly drop. In any case, it is recommended that CODE be asked to report annually to COU on enrolment and employment opportunities.

Recommendation C2

> It is recommended that steps be taken to inform potential candidates of the value of a PhD in many phases of government and industry, not only in research and development. The universities, individually and collectively, through agencies such as CODE, should discuss with the industrial and governmental employers steps to be taken jointly in order to overcome the shortage of Canadian students.

Recommendation C3

> It is recommended that the universities maintain the situation where Canadians and landed immigrants constitute at least 70% of the doctoral enrolment in any programme, at any one time, even though the number of landed immigrants may decrease.

Recommendation C4

> It is recommended that the universities, the provincial government, and granting agencies consider the remarks of the consultants and examine the extent to which the limit to student income deters Canadians from entering graduate work. Means of supplementing the income of professionally experienced students should be examined; increased contacts between faculty and industry could lead to increased industrial support.

Admissions

ACAP does not support the view held by the electrical engineering consultants, namely that admitted doctoral candidates should have first class standing and proven research ability. Many students who graduate with high second class honours have become excellent research engineers. The usual minimum standard of the better departments is a high B and all the consultants agree that high standards of admissions prevail generally.

Recommendation C5

> It is recommended that each Discipline Group monitor annually the admissions experience of each programme (post facto) and report on the quality of the admitted students to ACAP for transmission to COU.

CODE agrees with ACAP on the annual post facto analysis of admission practices (page H-3). The chemical engineering consultants have suggested "that should it be found that students have been accepted who, in the opinion of the committee, do not fulfill the minimum requirements, the committee advise COU that a recommendation be made to the requisite authority suggesting no BIU be awarded for that student". ACAP does not feel this to be necessary at the present since regular reporting by the Discipline Group should exert considerable pressure if an institution repeatedly admits students of a low standard.

Undergraduate-Graduate Relationship

Some consultants assert that each department should provide all levels of study: bachelor's, master's and doctoral. Some go so far as to say that a doctoral programme in each department is essential. CODE, on the other hand, feels that what is important for a good undergraduate programme is research and professional activity by the faculty, and that this can be carried forward without graduate students, although at present the research activity is most easily carried on through graduate programmes (page H-3). ACAP agrees with the position stated by CODE and indeed applies it to all subjects, not only engineering, but with the comment that in many fields it is not difficult for a professor to be active in research without having graduate students. We would point out that the other position would imply that no department should exist unless it can operate an effective doctoral programme, a view which we find impossible to accept. The absence of sufficient research and professional activity by professors would raise questions about the quality of a department and hence of its undergraduate offerings, whether or not it offered doctoral work.

Thesis Quality

Recommendation C6

> It is recommended that all doctoral thesis examining committees should have an examiner external to the university.

Since some of the consultants have made reference to the make-up of examining committees ACAP would wish to endorse this practice of including an external examiner.

Critical Size

We agree with CODE that there must be sufficient range of interaction for the student and that the judgment as to the presence of this interaction must include consideration of the involvement of persons outside the student's department and should include post-doctoral fellows and research associates as well as students. Although these planning assessments were vertical, as CODE suggests, each department was asked to state the extent of this interaction in its university. We agree that there is no *a priori* reason why a small school cannot provide as satisfactory an environment as can a large school. The question is not one of principle, but one of fact: does university A in fact provide the requisite environment for interaction for the average student in its department X?

Most of the consultants considered this question carefully and made specific comments but others provide no evidence that they examined the matter in any of the universities. While most agree that successful programmes can exist in small as well as large departments, the consultants still expect a wide range of courses to be offered. This in turn requires a certain number of students to make the courses economically feasible and academically stimulating.

Mobility of Students

The chemical engineering consultants are concerned about the lack of mobility of engineering students. They do not consider it a good educational experience to study for all three degrees, the bachelor's, the master's and the doctorate, at the same university. Such a programme leads to inbreeding and sameness and precludes any chance for the student to come in contact with different faculty, students, milieu and methods.

One sometimes hears a professor accept this in theory, but then say that in practice the student must not be prevented from going to the university of his choice. That view appears to us to be correct, provided the student's choice is made on sound academic grounds, based on good information of the opportunities that are available to him, and taking account, of course, of the undesirable aspects of remaining in one university.

Recommendation C7

> It is recommended that each Discipline Group and CODE develop proposals for making information on graduate work in all Ontario universities readily available to the engineering students, in some collective way and inform ACAP of the action taken. Each Discipline Group should report annually on the university last attended by the graduate students in each department.

Part-time Programmes

In 1972-73, 18% of the doctoral students studying engineering were doing so on a part-time basis. 65% of these students were Canadians and another 32.5% were landed immigrants. It would appear that these part-time programmes are being used by the profession to upgrade the skills and knowledge of its practising engineers.

The consultants seem divided on the issue of part-time programmes, some saying "such undertakings should be rarely encouraged" and others, "full encouragement should be given to part-time doctoral programmes." ACAP feels that there is a place for the part-time programme and that careful attention should be devoted to designing part-time programmes, bearing in mind the strengths of the departments. One of the dangers sometimes noted is that students become involved, under a part-time supervisor, in a project in an area in which the full-time staff has limited expertise; this is not recommended.

Recommendation C8

> It is recommended that at the present any part-time or non-resident doctoral work should be by individual arrangement and that experimentation in this type of programme be encouraged. It is also recommended that the research topic of the student accepted on a part-time basis be in a field in which the professors in the department have expertise. It is recommended that OCGS examine existing university guidelines in this area.

Cooperation

One of the main points that all the consultants agree upon is the need for increased cooperation both within and between universities. The chemical engineering consultants found a need for increased interaction between the engineers and the pure science faculties. Some of the other consultants felt the need for more communication and cooperation between the universities and industry and government. Lastly, more effective use could be made of the resources in the province if the universities themselves joined together in some form of cooperative endeavour. CODE endorses this last point quite strongly in its response, page H-4. Sharing of equipment, discipline meetings and an interchange of credits for graduate courses are a few of the methods listed by CODE that are to be encouraged on the way to making this cooperation a meaningful and workable venture. ACAP concurs with the statements made by the consultants and CODE and strongly supports their implementation.

ACAP intends to request that each Discipline Group report regularly to ACAP on interuniversity cooperative arrangements.

Faculty

Two sets of consultants found enough disquieting evidence in the engineering faculties of the province to suggest that the requirements for a faculty member, eligible to supervise graduate students, should be reviewed and enforced. ACAP takes no position on whether or not there should be a separate Graduate Faculty, but there must be a mechanism to ensure that only those faculty with proven research ability and productivity supervise graduate students.

Since this concern has been mentioned in other assessments, ACAP feels it is time that OCGS conduct a review of this area.

Time to Reach Degree

The electrical engineering consultants were concerned about the length of time taken to obtain the PhD. As they pointed out, the average student at one university took 13-20 months longer to complete his doctorate than his counterpart at another university. As a whole, they found the average time of study to be excessive.

Recommendation C9

> It is recommended that the universities report to ACAP (for OCGS) each year on the time taken by each graduating student to complete his doctoral studies.

IV. UNIVERSITY RECOMMENDATIONS

Engineering was split into five separate assessments, one for each of the five traditional fields of engineering. Two universities, Western Ontario and Windsor, do not administer their doctoral engineering work along these lines but rather on an interdisciplinary basis that cuts horizontally across engineering. For this reason, these two universities are being dealt with separately and not as part of the more standard approach evident in the five assessment reports. Similarly, Guelph also is included in this section.

UNIVERSITY OF WESTERN ONTARIO

The University of Western Ontario began to offer doctoral work in engineering in 1965. Since then, twenty PhDs in Engineering Science have been granted. From the beginning effort has been made to emphasise its interdisciplinary nature and there has been a limited number of areas in which the student may do his graduate training. At no point has a doctoral degree been given in the so called traditional fields of engineering.

There are seven main research areas in which a student may obtain a PhD in Engineering Science. They are 1. geotechnical 2. boundary layer wind tunnel 3. chemical and biochemical process development and design 4. material science 5. systems 6. applied thermodynamics and 7. applied electrostatics. Environmental engineering aspects can be studied in all these research areas except material science.

Western's response to the collective engineering picture gives the 1973-74 enrolment as 29 F.T. and 15 P.T. doctoral students. In the additional data given to ACAP, 18 of the 37 current students' programme of study outlined were in the chemical engineering field, 8 were civil, 5 mechanical, and 3 each in electrical and material science.

The chemical engineering consultants have provided evidence of that programme's being of good quality. The systems research area depends heavily on chemical engineering. ACAP, therefore, concludes that the research areas chemical and biochemical process development and design, and systems are of satisfactory quality.

The metallurgical engineering consultants have recommended that the Material Science programme become a part of an interdisciplinary programme rather than an exclusively material science one. This was in part based on the fact that the group is small and spends most of its time teaching at the undergraduate level. They are "carrying a large programme for a group which is subcritical in size." From the additional material supplied by Western, there is little evidence of interdisciplinary activity for students who might be doing research in this area. ACAP concludes that this area should not be operating at the doctoral level.

The areas of mechanical engineering doctoral research work are subsumed under the main research area, applied thermodynamics. The consultants indicate that the doctoral research connected with heavy water is of good quality but they raise very serious questions about the doctoral work in acoustics. They feel this area should be restricted to work at the master's level.

The civil engineering consultants did not make comparative judgments, but from some of the phrases used to describe the Boundary Layer Wind Tunnel Laboratory such as "internationally known", ACAP has no reservations in recommending continuance of doctoral work in this research area, even though it appears to have little interaction with other groups. The civil engineering consultants told us nothing about the geotechnical area and we, therefore, had difficulty in recommending a position to be taken with regard to this field.

The last research area, applied electrostatics, is the most difficult to assess. The electrical engineering consultants have recommended discontinuance of the doctoral programme. They feel the students are getting too narrow a training in electrical engineering. We observe, however, that the students are not considered to be studying for a PhD in electrical engineering, but rather for a general degree in engineering science. Although there are only a few faculty members in this area, they are internationally known. The main problem would, therefore, seem to be the extent to which the doctoral training in this area is of an interdisciplinary nature. From the data available to ACAP, we are unsure.

In the course of discussions with representatives of the University of Western Ontario, it became clear that the Faculty is involved in a thorough re-examination of its doctoral programme. It is committed to the concept of an engineering science PhD but is reconsidering the appropriate areas of research. While it is not entirely accepted by ACAP that all the activity is noticeably different from that in engineering departments elsewhere, we nevertheless believe that this intention of the Faculty should be encouraged. A corollary is that it must be very careful about the research areas in which it accepts PhD candidates; we have already commented on these and note the standard of quality seems variable.

These considerations have led us to formulate the following recommendation.

Recommendation C10

> It is recommended that the University of Western Ontario continue its examination of its PhD programme in engineering science, and put forward the resulting programme for appraisal, in particular delineating carefully the areas of research in which it feels it appropriate to accept students. In case a favourable appraisal is not obtained by October, 1976, admission of new students should then be suspended.

University of Windsor

Early in 1971, the Faculty of Applied Science at the University of Windsor began to examine the structure of graduate programmes within the Faculty in order to improve their operation, avoid needless and costly duplication of graduate course offerings and to attempt to create a greater cross-fertilization of research by involving faculty members from different engineering departments in various facets of a larger research plan. This examination led to the recommendation that Graduate Studies be operated on a divisional basis, with the seven undergraduate departments being consolidated under three graduate divisions, namely Engineering Process Design, Structures and Systems. The three divisions would each elect a chairman who would decide on course offerings and enrolment levels. The three chairmen, one elected member from each division, one graduate student and the Dean of Applied Science form a Coordinating Committee to oversee and coordinate the wishes of the Divisions. This plan was approved in spring, 1972 and is now being implemented.

Some of the traditional departments such as chemical and electrical fall completely in one division. All the rest are split between two as can be seen in the attached Table 1.

There are nine identifiable research areas, each of which have participating faculty from at least two of the old departments and these nine areas are in turn divided fairly equally among the three divisions.

The degrees awarded will retain the old titles, for example, a PhD in Chemical Engineering, but the interaction of the individual student with others in the Faculty will be greatly enhanced. Depending on his research topic, the student might take as many as half his courses from professors in other 'departments'.

The consultants' comments concerning Windsor vary, but a number of their reports imply some doubt or uncertainty concerning the relevant departmental programme, either with respect to the situation at the time of their visit, or in connection with its future direction. The chemical engineering consultants suggest that Windsor be reviewed in greater depth. The metallurgical engineering consultants recommend the integration of engineering materials faculty in the new divisional system. The mechanical engineering consultants call for more emphasis on master's work. In the case of electrical engineering the consultants indicate that good work is now being done in doctoral education in two fields, agree with the present plans for no significant growth in enrolment and for no expansion of fields, and go on to recommend a review after five years.

In view of these considerations ACAP feels the University of Windsor should be given time to produce a viable interdisciplinary system of doctoral engineering studies before that system is brought forward for appraisal. This appraisal would determine the level of quality in the new divisional system and whether or not significant interaction has been achieved between the staff and students of the various departments.

Table I

Organization of Engineering Doctoral Work at the University of Windsor

a. % of Department Involvement in each Division

Department	Engineering Process Design	Structures	Systems
Chemical	100%		
Civil	40%	60%	
Electrical			100%
Engineering Materials	50%	50%	
Industrial	10%		90%
Mechanical	60%	40%	

b. Departmental Research Interests

Department / Research Interests	Structures	Electric Power	Thermofluids	Systems and Signals	Human Factors	Mechanical Metallurgy	Physical Metallurgy	Water and Air Quality	Vibration and Noise
Chemical			x					x	
Civil	x		x			x		x	x
Electrical		x		x					
Engineering Materials	x		x			x	x		
Industrial				x	x	x		x	x
Mechanical	x		x	x	x	x			x

Recommendation C11

> It is recommended that the University of Windsor continue the reorganization of its doctoral work in engineering and submit all programmes (presumably these will be the three divisional programmes which are replacing the departmental programmes), for appraisal when the new system has been in operation sufficiently long to permit a valid appraisal. Enrolment of new students should cease after October, 1977, if a favourable appraisal has not been obtained by that date.

University of Guelph

The University of Guelph has for sometime offered an interdepartmental PhD programme in hydrology in which its Engineering School plays a part. It also plans to develop doctoral work in agricultural engineering, which it already offers at the master's level. There are no other programmes in agricultural engineering in the province.

The matter of the interdepartmental programme would appear not to be central to this assessment. It would not be inappropriate for the Civil Engineering Discipline Group to keep this programme in mind when carrying out the study called for in Recommendation C19. Nevertheless, it seems unnecessary to await the Discipline Group report to make the recommendation which follows.*

From the planning viewpoint, there seems no reason to do other than accept the University's intention to begin doctoral work in agricultural engineering, whenever it feels the time is ripe and the proposal has passed appraisal.

Recommendation C12

> It is recommended that the involvement of the School of Engineering in the hydrology doctoral programme at the University of Guelph continue and that the University begin doctoral work in agricultural engineering at a time in accordance with the University's plans, subject to normal appraisal procedures.

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* It may be noted that COU did not accept Recommendation C19.

V. CHEMICAL ENGINEERING

This section of the ACAP report will deal with the recommendations found in the chemical engineering consultants' report. There will be no reference made to Western or Windsor since these two universities were mentioned in a previous section. It is important that the consultants' report and the university and discipline group responses be read at the same time as this ACAP report.

Recommendation C13

> It is recommended that the departments take note of the consultants' recommendation 10 to group research activities in well defined areas so as to establish or reinforce teams, thus providing a more stimulating environment for students.

Recommendation C14

> It is recommended that McMaster University continue its doctoral work in chemical engineering according to its plans.

McMaster specializes in process simulation, waste-water treatment, polymer engineering, chemical reaction engineering and catalysis, and transport and separation processes, with stronger emphasis on the first two areas. The consultants feel that McMaster's goals for the future are "realistic" and appear to be "achievable and productive".

Recommendation C15

> It is recommended that the University of Ottawa continue its doctoral programme in chemical engineering according to its plans.

The University of Ottawa specializes in three main areas including thermodynamics and transport properties; kinetics, catalysis and reactor engineering; and transport processes. There has recently been a shift towards a greater environmental emphasis. The consultants encouraged Ottawa to keep up with changes in the areas of research and graduate teaching and move into these new areas whenever possible.

Recommendation C16

> It is recommended that Queen's University reevaluate its doctoral programme in chemical engineering in the light of comments made by the consultants concerning research activity of the faculty, the grouping of research areas, the awareness of new trends in the discipline, and the mobility of its bachelor's graduates, and submit the programme for appraisal at the time that the University considers appropriate. If a favourable appraisal has not been received by October, 1976, enrolment of new students should be suspended at that date.

Queen's University specializes in the following five doctoral research areas: biochemical and environment engineering, chemical kinetics and reactor design, process control and simulation, thermodynamics, and transport phenomena. These areas cover most of chemical engineering making a rather uniform distribution of effort. The publication records of only two professors are very good, all the rest being average or low. This raises questions as to the activities of the faculty since their connections with professional and scientific societies can be described as "only mildly active". The consultants feel alarm at the number of Queen's bachelor's graduates who undertake graduate work at the same institution.

On the optimistic side, the consultants note that "the very excellent development planning and programme forecasting suggests that the department's goals and future research activities will be relevant and responsive to the prevailing needs of the province".

ACAP suggests that Queen's might consider strengthening its present faculty, or alternatively, it might consider consolidating its existing wide scope of research areas. As to inbreeding of students, ACAP draws Queen's attention to Recommendation C7.

Recommendation C17

> It is recommended that the University of Toronto continue its doctoral programme in chemical engineering according to its plans, paying particular attention to Recommendation C7 regarding mobility of its graduates and to Recommendation C13 concerning grouping of research areas. It is recommended that the University of Toronto report to COU through ACAP by June, 1975 on action taken in regard to this Recommendation.

The University of Toronto lists eight areas of specialization, all of which show a rather uniform distribution of faculty effort. The exception is a marked emphasis on applied chemistry. The consultants would like to see an effort to group the staff in given areas of research instead of the present policy of allowing a staff member "to select his own path". The consultants did not find Toronto's statement on its plans particularly helpful and they offered no comment on it, other than to say that "it is doubtful whether any increase above the present enrolment would be beneficial to these new students or to the student body as a whole". The University of Toronto should also encourage mobility of its graduates to the benefit of other departments and of the students alike.

Recommendation C18

> It is recommended that the University of Waterloo continue its doctoral programme in chemical engineering according to its plans.

The University of Waterloo has grouped its research activity into five areas including biochemical and food engineering, extractive and process metallurgy, polymer science and engineering, mathematical analysis and control, and transport processes and kinetics. The scope is wide, covering a large part of chemical engineering but, there are defined groups to coordinate the programmes. Although the consultants considered the statement of goals and objectives "less positive and definitive" than others, they were pleased to note Waterloo's intention "to ensure research activities by the use of more post-doctoral fellows and hired research assistants (non-degree candidates) if this should become necessary".

VI. CIVIL ENGINEERING

The report of the civil engineering consultants contains a number of important recommendations of a general character.

Their discussion of the manpower situation supports our Recommendation C1. They suggest that it would be wise to expect rather fewer students than the totality of the stated university plans. Considering the uncertainty of the manpower analysis and the size of the numbers involved, ACAP does not feel it desirable to formulate any recommendations about individual enrolment. ACAP does advise each university to consider the likelihood that the doctoral enrolment in civil engineering may fall still further unless the fraction of Canadian students increases substantially from its present level of about 25%.

Their comments that the "study of a civil engineering speciality in depth necessitates increasingly...some graduate work", reinforces our Recommendation C2 concerning publicizing the value of graduate work.

They argue for more part-time work and closer liaison with industrial and governmental laboratories. Recommendations C2 and C8 touch on this point.

The consultants on pages A-18 and A-35 express their concern that students tend to remain for graduate study at their undergraduate universities, often being unaware of offerings elsewhere. We make recommendations on this problem in Recommendation C7.

The consultants perceive a need for "more consistent requirements of acceptance...between universities". Although we do not recommend the particular remedy they suggest we do make Recommendation C4 in this connection.

On matters specific to civil engineering, the consultants stress the need for more emphasis on fields other than structures. They call for less stress on "traditional areas, particularly structural engineering, and more stress on multidisciplinary education, environmental engineering, and transportation". They suggest that "change of programme emphasis in civil engineering (will) lead to some growth in faculty when generally universities are expecting a fairly static period". On pages A-49 and A-50, they quantify this shift by asking for a 20% reduction in doctoral enrolment in structures (i.e., a drop of about 15 students) together with a corresponding increase, roughly equally in transportation and water resources. Perhaps rather surprisingly they then suggest that no university should offer a new field at the doctoral level. (On page A-52 they also suggest that no university reduce "the range of its doctoral programmes" but on page A-51 they add "unless that university desires otherwise".)

The consequence of this stance, based on pages A-25 to A-29, is summarized in Table 2.

Table 2

CIVIL ENGINEERING

Possible Consequences of the Consultants' Recommendations on Enrolment and Field Emphasis

Universities	Fields				Order of Magnitude of Enrolment
	Geo-technical	Structures	Water Resources	Transportation	
Carleton	S	R	-	I	6
McMaster	-	S	I	-	10
Ottawa	S	R	I	-	17
Queen's	S	R	-	-	8
Toronto	S	R	I	I	25
Waterloo	S	S	I	I	30

LEGEND: R - reduce enrolment
S - static enrolment
I - increase enrolment

NOTE: Guelph, Western Ontario and Windsor are not included in the chart as they are dealt with elsewhere. (See section on University Recommendations.)

There are difficulties in accepting these recommendations. For example, if one asks what the shifts of enrolment from structures would be, to total around 15, one comes up with something like: Carleton 2, McMaster 0, Ottawa 3, Queen's 2, Toronto 4, Waterloo 4. Looking then at transportation one finds doctoral programmes at Carleton, Toronto, and Waterloo which might increase by 2 or 3 at each place. One has to ask if this is the best way to develop more high quality doctoral work. Would it be a better strategy to encourage Carleton, for example, to build a somewhat larger group than 3 or 4 students? There is another concern. Are all the transportation groups of equal promise as places to do doctoral work? If not, should some be strengthened more than others? If we really believe in penny-packet enrolments, could a fourth university perhaps enter this field? The consultants' report provides no satisfactory discussion of these questions to justify its proposals.

Equally unsatisfactory, and perhaps more basically disturbing, is the consultants' failure to give any discussion whatsoever (with three small exceptions) of the facts and reasoning which led them to conclude that all existing programmes are satisfactory. This may be so, but the rationale is far from clear. As the appended correspondence (Appendix 1 to this section) shows, the consultants decline to discharge their terms of reference, in particular C3c and the paragraph following C3d. (See Appendix D.)

In particular, although the matter of critical academic enrolment size is discussed in generally acceptable terms, in that the proposition is stated that there is no a priori reason to assume a small school cannot provide as satisfactory an environment for a PhD student as a big school, the consultants neither state the characteristics of such an environment nor do they make any effort to show that it exists in the several small programmes they examined. Although it is no doubt possible to make the justification in several cases, nevertheless a question must still loom unsettled as to the academic strength (from the potential students' viewpoint) of several of the programmes, namely Carleton, Guelph, McMaster, and perhaps Ottawa and Queen's. (None has been appraised.) Of course the consultants' report, due to the lack of rationale in it, gives no reason to suppose that the larger departments are necessarily of suitable quality either.

ACAP cannot justify to itself recommending the acceptance of the consultants' plan, calling as it does for static enrolment, small shifts of emphasis in fields, and no new developments in any department. We feel that the question of the best way to develop doctoral work in transportation and water resources must be more carefully canvassed and that whatever the answer be it must be adequately justified. Some evaluation of the quality of the programme in each broad field at each university must be available before we can make any credible recommendation.

ACAP would like, at this point, to draw attention to the Discipline Group's response, Appendix B. The members of the group feel the consultants did not "seize their unique opportunity to make quality judgments" and failed to "address themselves to the question of quality in the planning function in their conclusions and recommendations." The group thinks that a statement that "documents the sundry strengths and weaknesses, if they exist, could well increase the value to those on whom the responsibility for planning ultimately rests". ACAP therefore makes the following recommendation.

Recommendation C19

> It is recommended that COU recommend the continuance of the embargo on the funding of any new programmes in civil engineering until COU has accepted a Discipline Group report dealing adequately with the future role of each department in respect to the different fields of doctoral research, paying particular attention to the relative strengths and weaknesses of each department and the change in emphasis on fields recommended by the consultants. The report should be submitted to ACAP by December 31, 1974.

We regret that this recommendation is necessary. We note (page A-5) that the Discipline Group had not prepared for the consultants the report called for by the agreed procedure (page D-6). We note also that the consultants state that they "have formed (their) own judgement about the strengths of different civil engineering departments and the areas in which they are likely to be able to attract high-quality students" - we regret that the consultants are not willing to share these judgments with the Ontario university community which employed them.

APPENDIX 1

NOVA SCOTIA TECHNICAL COLLEGE
P. O. BOX 1000
HALIFAX, N. S.

CIVIL ENGINEERING

21 February 1974

Professor M.A. Preston
Executive Vice-Chairman
Advisory Committee on Academic
Planning
Council of Ontario Universities
102 Bloor Street West
Toronto M5S 1M8, Ontario

Dear Professor Preston:

Further to our recent telephone conversations, I have now heard from all my colleagues who fully agree with my letter to you of 4 December 1973.

As mentioned in this letter, we did not discuss the question of quality in our Report since none of the civil engineering doctoral programs were found to fall below minimum acceptable standards.

Moreover, we did not feel the need, nor were we required by our terms of reference, to make relative quality judgements regarding the strengths or weaknesses of individual areas or departments, because in our Report we did not recommend any change in the number or the range of doctoral programs offered by any school, including the various areas of specialization of the smaller universities.

Since the civil engineering discipline group, as well as most universities, find our Report on the whole acceptable, we think that little is gained by getting into an area which might be interpreted as an appraisal or accreditation assessment.

Yours sincerely,

G. G. Meyerhof, Head
Dept. of Civil Engineering

lb
c.c. J.L. Boulet
W.W. Eckenfelder
B.V. Martin

NOVA SCOTIA TECHNICAL COLLEGE
P. O. BOX 1000
HALIFAX, N. S.

CIVIL ENGINEERING

4 December 1973

Professor M.A. Preston
Executive Vice-Chairman
Advisory Committee on Academic
Planning
Council of Ontario Universities
102 Bloor Street West
Toronto M5S 1M8, Ontario

Dear Professor Preston:

After returning from the west coast, I found your letter of 29 November and enclosures, which I read with interest.

In reply and following our terms of reference, we had not discussed the question of quality in our report since, in our opinion, none of the civil engineering doctoral programs were found to fall below minimum acceptable standards.

I am looking forward to the comments of my colleagues, in this regard.

Yours sincerely,

G. G. Meyerhof, Head
Dept. of Civil Engineering

lb

c.c. J.L. Boulet
W.W. Eckenfelder
B.V. Martin

ADVISORY COMMITTEE ON ACADEMIC PLANNING
Ontario Council on Graduate Studies

Professor M. A. Preston
Executive Vice-Chairman

COUNCIL OF ONTARIO UNIVERSITIES
102 Bloor Street West, Toronto 181, Ontario
(416) 920-6865

Postal Code: M5S 1M8

November 29, 1973

Mr. B. V. Martin
Prof. G. G. Meyerhof
Prof. W. W. Eckenfelder, Jr.
Dr. J. L. Boulet

Gentlemen:

I am enclosing all the university comments we have received on your planning assessment report and the formal response from the Discipline Group. You will recall that it is intended to publish these statements.

You will see from the comments that there is considerable dissatisfaction in the universities and in the discipline group with your failure to come to terms with your task of giving us your findings on the relative quality of the doctoral work in the different areas of civil engineering in the different departments. We on ACAP have to agree that one of the most important aspects of the terms of reference you undertook is the statement of strengths and weaknesses of departments, and that without it the report lacks credibility. If you are asserting that all fields offered for doctoral work are competently dealt with wherever they are offered, it will follow that civil engineering is a paragon amongst disciplines. Even if true, it does not help the universities to decide which areas to strengthen.

In one of the few specific comments, you do suggest that McMaster should emphasize earthquake engineering. Do you think its work in water resources is strong enough that it should seek to expand or maintain that, or, when you recommend greater emphasis on water resources, do you expect this to be achieved at Ottawa, Toronto, Waterloo and Windsor for example? McMaster (and the others) would like to know. You tell the University of Western Ontario to emphasize boundary layer wind tunnel work; but what about their geotechnique? Since Guelph now has 5 students in its hydrology programme, how can it be exploiting its unique facilities for agricultural engineering if its enrolment becomes 4 to 7? Is it expected to cut back on hydrology? To consider this, it would be necessary to know how valuable Guelph's hydrology work is and how substantial is the potential of its agricultural engineering programme.

I mention these points only as examples of the kind of question on which your advice would be helpful. The general point is that your judgments of quality by department and by area are important. You recommend that transportation be strengthened; we ask, where? If all the departments say "here", how are decisions about resource allocation to be made without the quality judgments you were expected to give?

....2/

One of the aspects of academic quality has to do with the size of the student enrolment. You will see from the university responses that there is some difference of opinion. The official position of COU, recently adopted, is as follows:

"The quality of graduate programmes is partly dependent on size, and for each programme, depending on how it is designed and its scope, there is a minimum size of enrolment below which quality may suffer. That number cannot be expressed for the discipline as a whole but only for individual programmes depending on their purpose, their resources and their design."

Recommendation 4 on page 52 of your report is not inconsistent with the above statement, but you do not indicate what criteria determine the "satisfactory environment." In ACAP we have identified two areas which we believe should be examined in this connection. One is the opportunity for the students' development through informal intellectual discussion with a peer group with common engineering or scientific interests. This peer group need not consist only of students; it may also include post-doctoral fellows. It need not be confined to one department, but may include students in other departments if there is a real sharing of research interests. The second main area for consideration has, we feel, to do with graduate courses. Assuming that a course with, say, 5 or 6 students who interact is a much more satisfactory experience than one with 1 or 2 students, we see that the desirable enrolment size is a function of course structure. If there were a programme which did not require courses, this second criterion of size would not apply. But if it is felt that students should take a substantial number of courses (as appears to be the case in all the Ontario departments), then the consideration is valid and the situation needs examination.

It appears that some of our departments plan enrolments as small as 6 to 12. It may be that some of these departments, because of specialization, course structure, post-doctoral and master's population and interdepartmental collaboration, offer an academically sound experience for the student, while other departments with the same enrolment may not. Each case needs evaluation separately.

This brings us back again to the desirability of your giving a detailed analysis of each university. We request evaluation of quality by area of study of each department, including an analysis of the kind of intellectual milieu established for a student by the enrolment size.

I hope you realize that we have a problem of reconciling the reports of the consultants on the various engineering disciplines. One report of which there seems to be pretty general approval is that dealing with electrical engineering. Of course not all its details are accepted by everyone, but the style and coverage of the report has not been attacked. I enclose a copy, since it may make clearer what I have been trying to say in this letter.

After you have had a short interval to consider the letter, I shall telephone Professor Meyerhof to discuss the mechanism of your response. We need your assistance.

Yours sincerely,

M. A. Preston/ee

M. A. Preston

MAP/cew
Enclosures.

VII. ELECTRICAL ENGINEERING

This section of the ACAP report will deal with the recommendations found in the electrical engineering consultants' report. There will be no references to Western Ontario or Windsor since these two universities were mentioned in a previous section. It is important that the consultants' report and the university and discipline group responses be read at the same time as this ACAP report.

Recommendation C20

> It is recommended that the Discipline Group annually identify those areas of electrical engineering which they consider relevant to the present and future needs of Canada and make their findings available to the granting agencies and various associations of industry in order to stimulate a continuing dialogue with industry.

Other Discipline Groups might also consider this recommendation.

Recommendation C21

> It is recommended that Carleton University continue its doctoral work in electrical engineering according to its plans.

The work in electrical engineering at Carleton is divided into two departments, Electronics and Materials Engineering which includes solid state device electronics, circuits and circuit theory, microwave electronics and electron beam systems and processes and the Systems Engineering programme which concentrates on information systems such as communications and signal processing, decision and control, digital systems design and software engineering. The coverage within these two areas is well integrated, coordinated and appropriate for PhD training. The enrolment increase proposed by Carleton is within the competence and capability of the present staff.

Recommendation C22

> It is recommended that McMaster University continue its doctoral work in electrical engineering according to its plans.

McMaster has outstanding strength in three areas of graduate research and has plans to strengthen a fourth. These are communications and data processing, modelling and design, materials and devices and, lastly, medical electronics. The electrical engineering programme at McMaster is of high quality, with a productive and dynamic faculty.

Recommendation C23

> It is recommended that the University of Ottawa continue to offer a doctoral programme in electrical engineering restricted to theses in digital communication systems and large-scale systems. This limited programme is to be appraised as soon as possible. Enrolment of new students should cease as of December, 1975 if a favourable appraisal has not been obtained.

The department at Ottawa specializes in three areas, communication systems, control and systems, and computer engineering. With a faculty of 11, the consultants felt that they were spread over a rather large area of electrical engineering. A small department with a small number of staff and students can operate an effective doctoral programme only with competent professors, complementary fields of study and an adequate research environment. The consultants recommend discontinuing the programme. ACAP has considered both the consultants' report and the university's comments and has concluded that Ottawa has a contribution to make to graduate electrical engineering study in operating a specialized programme of limited scope and enrolment.

Recommendation C24

> It is recommended that Queen's University continue its programme in electrical engineering concentrating in the communications and systems fields, with occasionally a student in cognate areas of electronics and energy processing. Any proposed substantial developments in these latter two fields would be submitted for appraisal. It is also recommended that the department maintain enrolment at its present level.

The areas of specialization at Queen's are communications, systems, electronics, and energy processing. The consultants state that the work in communications is good but is only fair in systems, and that the Department should not offer a programme in the latter two fields on a regular basis. However, we suggest that an occasional student be allowed to do a thesis in one of these fields. ACAP accepts the consultants' view about enrolment which was made on academic grounds, not for planning reasons.

Recommendation C25

> It is recommended that the University of Toronto continue its doctoral work in electrical engineering according to its plans.

Graduate work at the University of Toronto covers seven areas including communications, computers, control, power devices and systems, solid state electronics, wave sciences, and biomedical electronics. The coverage of these fields is more than adequate and Toronto's "star-studded" faculty are spread over the seven areas indicating significant breadth across the department. The consultants conclude that the Toronto department compares favourably with any of the major institutions in North America.

Recommendation C26

> It is recommended that the University of Waterloo continue its doctoral work in electrical engineering according to its plans.

The University of Waterloo concentrates in five major areas including computers and communications; control, systems and networks; devices, circuits and materials; power engineering; and, antennas and electromagnetic engineering. There are two minor fields, bioengineering and electroacoustics, and these fields should be limited in size to the present level of activity. With Waterloo's highly competent faculty and well equipped facilities, there is no question that the enrolment level planned by Waterloo can be accommodated.

VIII. MECHANICAL ENGINEERING

There are a number of general recommendations and comments made in the mechanical engineering consultants' report that are aimed at the system as a whole. Recommendations for the individual universities follow this more general section.

The mechanical engineering consultants do not anticipate any oversupply of mechanical engineers. They believe no "artificial edict" is necessary to control the number of PhDs. On the contrary, they suggest the problem will be one of availability of good students. The consultants think that Ontario might, in fact, have a shortage of mechanical engineers.

"Traditional classical" versus "applied" research projects and a shift in emphasis of study are the next problems attacked by the consultants. They feel that the doctoral education of today should shift more towards project and design activity. To this end, they advocate increased dialogue and cooperation with outside agencies such as industry and government. "If we look at the problems before us today in the fields of energy, transportation, or the environment, it is apparent that there are many gaps in the knowledge which should be attacked systematically to provide the basic design data which is essential to advances in engineering and advances generally in technology on the broad front". The consultants also recommend a change in emphasis in fields of study. Some areas of research that need to be developed are listed on page A-14.

The consultants do not condone departments that attempt to be good in all fields. They feel specialization is the key and that "considerable selectivity is required in the choice of a particular area of concentrated effort". This choice of areas of concentration should be left up to the universities. ACAP agrees with this outlook but notes that the initiatives of each department in Ontario are matters for collective consideration and advice. ACAP advises the departments to consider the consultants' suggestions noted in the addendum and asks that they report on progress made after a year of mature consideration. After this time, the Discipline Group, in its normal role, would continue to consider the development of new areas of graduate study and the possible entry into neglected fields in mechanical engineering in Ontario and would make recommendations to ACAP where change is desirable.

Another problem the mechanical engineering consultants addressed was the one of faculty age. Since the Ontario universities have been through an expansionary period in the sixties, a large proportion of the faculty is below 45 years old, consequently lacking something in maturity and industrial experience. The consultants feel that although the retirements in the next several years will be few, the universities should take these opportunities to introduce new blood by appointing faculty with industrial experience.

It is important that the consultants' report and the university and Discipline Group responses be read at the same time as this ACAP report.

Recommendations

Recommendation C27

> It is recommended that Carleton, McMaster and Queen's Universities continue their doctoral programmes in mechanical engineering and during the coming year give careful consideration to the feasibility of a stronger development of foci of interest in the special areas of strengths suggested by the consultants. The Universities are requested to report to COU and OCGS, through ACAP, during the Fall of 1975, on the results of these considerations.

The mechanical engineering consultants, in their addendum, give valuable suggestions for focusing research activities in each department. These suggestions appear to be based on both planning grounds and grounds of academic quality, but alternative research foci may not be ruled out. Consequently, ACAP recommends that the three doctoral programmes continue but that each university note the consultants' comments and report on progress in a year's time.

Recommendation C28

> It is recommended that, if the University of Ottawa wishes to reactivate a doctoral programme in mechanical engineering, it give careful consideration to allowing some further maturing of the department before applying for appraisal.

The consultants, in their remarks concerning the University of Ottawa, page A-17, recommend that the work in the Mechanical Engineering Department be incorporated in an interdisciplinary programme leading to an undesignated PhD degree. ACAP notes the university response, page C-14, which states that they wish to "reactivate" the doctoral programme, before discussion of this new proposal. We do not at this time make a recommendation on the future form of engineering PhD work at the University of Ottawa. There appear to be no planning reasons why there should not be a programme at Ottawa in mechanical engineering, but the consultants have serious reservations about the suitability of a number of the research projects of the department and about the limited industrial experience of its staff members.

Recommendation C29

> It is recommended that the University of Toronto continue its doctoral programmes in mechanical engineering in its Department of Mechanical Engineering and the Department of Aerospace Studies and Engineering. ACAP suggests that the University consider the consultants' recommendation of a greater concentration of research activities of the Department of Mechanical Engineering on major problems of national concern. It is recommended that the University inform COU and OCGS through ACAP, during the fall of 1975, of any decisions taken.

We draw the attention of the University of Toronto to the consultants' suggestion that the Department of Mechanical Engineering concentrate research on problems of major, national concern. UTIAS should note the consultants' comments on the need for selectivity within the broad spectrum of the expertise of the staff, in such areas as plasma science, low density gas dynamics, subsonic aerodynamics, flight dynamics, shockwave phenomena and noise. The consultants also favour increased interaction with work in related fields on the main campus.

Recommendation C30

> It is recommended that the University of Waterloo continue its doctoral programme in mechanical engineering. ACAP suggests that the University consider the consultants' recommendation of a greater concentration of research activities on major problems of national concern. It is recommended that the University inform COU and OCGS through ACAP, during the fall of 1975, of any decisions taken.

ACAP notes the consultants' suggestion that the department concentrate in Production and Automation. We also take note of Waterloo's response which lists strengths in other areas. We recommend that Waterloo consider the consultants' idea of developing foci of research interest and report on any action thought desirable.

The University of Western Ontario and the University of Windsor have not been discussed here, since there is no need for any recommendations in addition to those in the section on University Recommendations, page 20.

IX. METALLURGICAL AND MATERIALS ENGINEERING

This section of the ACAP report will deal with the recommendations found in the metallurgical engineering consultants' report. There will be no references to Western Ontario or Windsor since these two universities were mentioned in a previous section. It is important that the consultants' report and the university and discipline group responses be read at the same time as this ACAP report.

Recommendation C31

> It is recommended that the universities take note of the consultants' recommendations 1, 2, 3b and 3c, dealing with the weakness in certain fields of study in the province and that the Discipline Group report to ACAP on any action taken in consequence of these reommendations.

The consultants find it surprising that there is so little effort in the ceramics and glasses fields of study. Even more striking to them is the absence of any work in polymers in the Departments of Metallurgy and Materials Engineering. In their first few recommendations, they consider it very important to rectify these neglected areas and ACAP feels this is a job for the Discipline Group. They also feel it is important to strengthen already existing areas of study and in particular create at least one internationally known centre of materials science activity.

Recommendation C32

> It is recommended that McMaster University continue its doctoral programmes in materials science and extractive metallurgy, and noting the strength attributed to these programmes by the consultants, make a report in the fall of 1975 on the following suggestions for improvement:
>
> a. recruitment of students with physics and chemistry backgrounds
>
> b. strengthening of the extractive metallurgy faculty
>
> c. collaboration with Toronto

The materials science programme at McMaster is considered by the consultants to be the best programme of this kind in Ontario and probably in Canada. It is the only programme that covers adequately the basic science related to all classes of materials including polymers. The enrolment could be easily doubled without developing the need for any significant increase in resources allocated to the programme, but enrolment, here, is limited as in so many other areas of engineering, by the number of qualified students.

The extractive metallurgy programme, although not as strong as the materials science one, provides very suitable research for the doctoral thesis. The range of the programme is, however, inadequate but cooperation with other McMaster Departments and with the University of Toronto will greatly enhance the operation of this programme.

ACAP suggests that McMaster consider the points put forward by the consultants and that the university report to ACAP on any action taken with regard to these recommendations.

Recommendation C33

> It is recommended that Queen's University continue its doctoral work in physical metallurgy and discontinue the doctoral programme in extractive metallurgy and mineral engineering as it now exists and replace it by an enlarged programme involving professors in other departments as suggested in the consultants' report. This new programme should be appraised and this should be completed by December 31, 1976. If Queen's does not wish to enlarge its programme in extractive metallurgy and mineral engineering, the present programme should be put forward immediately for appraisal, ceasing to enrol new students by June 30, 1975, if a favourable appraisal is not obtained.

The consultants consider the programme in physical metallurgy at Queen's a good, traditional type of programme taught by young and talented faculty. Although it would make a suitable base on which to build a programme in materials engineering, the consultants do not recommend that Queen's do so.

The programme in extractive metallurgy, on the other hand, is not so well off. It is seen by the consultants to be inadequate in its present form, with too small a range of courses, too limited an amount of research activity, and ineffective interactions with other departments and programmes. But the consultants feel it is necessary to strengthen and develop this field, to provide the needed PhD graduates and maintain Queen's part in a history of leadership in Canada in mineral engineering, geology and related fields.

The enlarged programme of extractive metallurgy is envisaged by the consultants to consist of support from the Departments of Metallurgical Engineering, Chemical Engineering, Mining Engineering and Geology. ACAP realizes that cooperation cannot be legislated, but it must have some formal structure in order to make the various professors aware of their part in a cooperative venture and secure the recognition of their departments for the effort devoted to the venture.

Recommendation C34

> It is recommended that the University of Toronto continue its doctoral programmes in its Department of Metallurgy and Materials Science. It is suggested that Toronto give careful consideration to the consultants' recommendations concerning broadening the programmes and it is recommended that the University report to COU through ACAP by September, 1975, on any progress made in this direction.

Toronto has an international reputation for its graduate work in extractive metallurgy. However, the range of courses is limited; this situation could be improved through cooperation with McMaster. The consultants feel this would provide a good base from which to develop a programme in mineral engineering and extractive metallurgy and they advise the university to do so.

In addition to those who work in extractive metallurgy there is another group of professors in the department who describe their work as physical metallurgy and materials research. These people working with added specialists in polymers and electrical and optical properties of materials would form a group capable of mounting a substantial programme in materials engineering.

Recommendation C35

> It is recommended that the University of Waterloo continue its engineering doctoral work in extractive and process metallurgy and in metallurgical engineering and materials science according to its plans.

Waterloo has no specific programme in materials and does not offer a PhD labelled as metallurgical engineering or any allied field. Instead, students are trained in extractive metallurgy in the Department of Chemical Engineering and there is a group of metallurgists and materials scientists in the Mechanical Engineering department. The consultants felt their effort was of such high quality that if this group were constituted as an administrative unit, they would be the strongest and most comprehensive graduate programme in materials engineering in the province. The consultants recommend setting up a separate administrative structure. However, the unit (all in one department) appears to function well without separate administration and ACAP does not feel that such a structure is imperative. Waterloo will, no doubt, consider the consultants' suggestion.

X. MINING ENGINEERING

Queen's University offers the PhD in mining engineering. This is unique in the province. Although the enrolment is small, the programme appears to fill a distinct need. The University projects no enrolment increase, showing only 4 students in 1977-78.

On the basis of the statement of future plans made by the University, we recommend:

Recommendation C36

> It is recommended that Queen's University continue its doctoral work in mining engineering in accordance with its plans.

XI. INDUSTRIAL ENGINEERING AND SYSTEMS DESIGN

This section of the ACAP report will deal with the recommendations found in the industrial engineering and systems design consultants' report. It will contain recommendations on the Universities of Toronto and Waterloo. ACAP suggests that the University of Windsor take careful note of the recommendations made in this consultants' report but at this time ACAP makes no specific recommendations on doctoral work in industrial engineering at Windsor since it is part of the earlier Recommendation C11.

The general recommendations in this report echo many of those found in the earlier consultants' reports. These consultants' estimates of manpower supply and demand closely follow those made by the other consultants and are discussed more fully in the second part of this ACAP report. Related to this is the need to increase the Canadian content in engineering programmes. Recommendations C1 and C3 refer specifically to these two points.

ACAP notes that the universities do not consider the establishment of a coordinating committee to be very important. We hope that talks are normally taking place between the three departments and that they will continue. ACAP feels there is no need to set up a formal Discipline Group to ensure discussions but if those concerned wish to do so it can be arranged.

Again, as in the other consultants' reports there is seen to be a need to circulate information to the student concerning the various programmes in order to ensure he selects the programme best suited to his objectives. This problem has been addressed by Recommendation C7.

ACAP endorses the consultants' recommendations 6,7,8,9 and 11 and does not wish to make any particular comments on these recommendations.

Recommendation C37

> It is recommended that the University of Toronto continue its doctoral work in human factors engineering, management information systems and operations research.

In its response to the consultants' report, the University of Toronto seems in general agreement with the recommendations made concerning its programme. ACAP notes that the Department has already made the appointment suggested in recommendation 3.

As far as future enrolment is concerned, ACAP suggests the university continue to expect approximately the same enrolment as it now enjoys. In accordance with standard appraisal procedures, a shift in fields of specialization to programmes in health systems and energy systems would require referral to the Appraisals Committee to determine whether or not an appraisal is necessary.

A review of the enrolment expectations would be made at that time. For the present, a continued output of 3 or 4 PhDs a year should be expected by the university. This should not be regarded as a quota but rather as the outcome of the present situation of fewer qualified students and falling enrolments. It should be noted that the University of Toronto has maintained a high percentage of Canadians in its industrial engineering programme in comparison to other engineering programmes both in the University of Toronto and elsewhere.

Recommendation C38

> It is recommended that the University of Waterloo continue its doctoral programme in systems design.

ACAP takes note of the response of the University of Waterloo to the consultants' various recommendations concerning the Department's isolation, its "soft" course content and the quality of recent staff appointees. Despite the possibility that enrolments may increase in this field and despite the comments from the University, ACAP considers that Waterloo should give careful attention to the consultants' recommendations for strengthening the programme before increasing the enrolment.

APPENDIX A

REPORT
OF
CIVIL ENGINEERING CONSULTANTS

to

ADVISORY COMMITTEE ON ACADEMIC PLANNING
COUNCIL OF ONTARIO UNIVERSITIES

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September, 1973

Contents

		Page
Chapter 1	Introduction	A-1
Chapter 2	Scope of Civil Engineering Education	A-8
Chapter 3	Graduate Studies and Enrolment	A-11
Chapter 4	Faculty	A-22
Chapter 5	University System	A-25
Chapter 6	Student Views	A-34
Chapter 7	Manpower Forecasts	A-39
Chapter 8	Five Year Plan	A-46
Chapter 9	Conclusions and Recommendations	A-52

Our choicest plans have fallen through,
Our airiest castles tumbled over,
Because of lines we neatly drew
And later neatly stumbled over.

Piet Hein.

Chapter 1

INTRODUCTION

1.1 General

As part of a planning assessment for the doctoral programmes in 1973-78 at universities in the Province of Ontario, the present consultants were retained by the Advisory Committee on Academic Planning, Council of Ontario Universities, to make a planning study of the doctoral programmes in civil engineering. In this connection they were furnished with documents related to the coordination of assessments in engineering, material prepared by the discipline group in civil engineering and the universities giving details of the civil engineering faculty, undergraduate and graduate students, physical and support facilities and proposed plans for the future of doctoral work. The consultants were also provided with copies of the Ring of Iron (A Study of Engineering Education in Ontario, December, 1970), the statements on it by the Council of Ontario Universities, the Deans of Engineering, the Ontario Council on Graduate Studies, and the Association of Professional Engineers of Ontario and other related information.

The consultants were asked to report on the adequacy of the present state of doctoral work in civil engineering in Ontario universities in general and in each university, where applicable, and to make recommendations for the development of doctoral work in fields of this assessment in Ontario between 1973 and 1978, taking into consideration such plans as may be developed by the discipline group in civil engineering.

1.2 Terms of Reference

The terms of reference provided to us by ACAP were as follows:

C.1. Consider the two special documents related to the coordination of the assessments in Engineering, viz. Engineering PhD Planning and Assessment Procedures, Statement on PhD Studies in Engineering Studies in Ontario, and the material prepared by the discipline group and the universities and obtain other data they may require to carry out the tasks detailed below. They shall be provided with copies of Ring of Iron, the COU statement thereon, and the CODE, OCGS and APEO responses. They may obtain data and views from any relevant source, such as, for example, employers of holders of graduate degrees, professional and learned societies, federal agencies. The campus of each interested university shall be visited by at least two consultants. Consultants shall arrange their schedule of visits to the universities in consultation with ACAP to ensure uniformity. Reports of appraisal consultants are privilege documents and are not to be made available to ACAP consultants. Consultants shall meet with the discipline group near the beginning of the work, during the work as they consider necessary, and immediately before preparing their final report.

C.2. Report on the adequacy of the present state of doctoral work in civil engineering in the province in general and in each university where applicable, discussing the following:

a. coverage of fields and specialties, and extent of activity in each

b. faculty quality and quantity

c. nature of programmes offered

d. enrolment size and distribution amongst universities and divisions

e. quality of student body; admission requirements

f. relationship to related disciplines and to the profession

g. physical facilities

h. other matters considered by the consultants to be significant.

C.3. Make recommendations for the development of doctoral work in fields of this assessment in Ontario between 1973 and 1978, taking into consideration such plans as may be developed by the Discipline Group, and, without limiting the generality of the foregoing, dealing with the following points:

a. Desirable doctoral programmes to be offered in the province, considering both possible limitations or reductions of existing programmes and creation of new programmes and new kinds of programmes including the appropriateness of part-time programmes. In particular, consider if there should or should not be more activity in fields now producing few graduates in Ontario and also the desirability of developing further application-oriented and interdisciplinary work and industrial involvement.

b. Desirable provincial enrolments, year by year, in the doctoral study in civil engineering and in the major subject divisions where appropriate. One should consider the need for highly trained manpower and also the general cultural and societal factors which may lead students to pursue doctoral work in engineering. In considering manpower needs, one should take account of the "market" available to graduates (at least all of Canada) and of other sources of supply for that market. Results of forecasts of high level manpower employment should be treated with due caution and only in a clearly balanced relationship with cultural and societal needs.

c. Distribution amongst the universities of responsibility for programmes and for specialties where appropriate, including consideration of the need for any increase or decrease in the number of departments offering doctoral work and including consideration of areas of collaboration and sharing of facilities at regional level and across the province. Consider techniques for involvement in doctoral supervision of professors in departments which do not take doctoral students in their fields, and the extent to which such activity is desirable.

d. Distribution of enrolment amongst the universities, showing desirable ranges of enrolment.

In all cases, it is important that the rationale for the recommendations be clear; this is especially important for items c. and d.

C.4. It is permissible for consultants to recommend appraisals of individual programmes. This would arise if consultants were to suspect that a programme would be found to be wholly or in part below minimum acceptable standards; and appraisal by the Appraisals Committee is the means of settling the question. It is recognized that this action would be infrequent. In carrying out planning assessments in some disciplines, consultants find there to be an excess or deficiency of programmes in a given area of study, where all of the existing programmes could pass an appraisal, they may, subject to their own judgements of relative quality and of other factors (a task outside the terms of reference of the Appraisals Committee), recommend where enrolment should be changed in accordance with the possibilities indicated in section C.3. (c).

1.3 Consultants' Procedure

After an initial meeting with the Discipline Group in Toronto on May 30, 1973, we visited the universities according to the following schedule.

University	Consultant			
	Meyerhof	Martin	Eckenfelder	Boulet
Carleton	June 18	June 18		July 11
Ottawa	June 19	June 19		July 11
Windsor	June 20-21	June 20-21		June 20-21
Toronto	June 22 & July 13	June 22 & July 13	June 22	June 22
Waterloo	July 9-10	July 9-10	July 9-10	
Western Ontario	July 11	July 11	July 11	-
Guelph	July 12	-	-	July 12
McMaster	July 12	July 12	July 12	July 12
Queen's	July 16-17	July 16-17		

At each university the basic schedule was as follows:

1. Meeting with chairman and principal faculty with all consultants.
2. Consultants divided and met faculty in each main study area.
3. Consultants met present and past PhD students without faculty.
4. Consultants met faculty from supporting departments.
5. Consultants met supporting service representatives including, library, computer, workshops.
6. Consultants met separately with
   (i) President or Vice-President of the university.
   (ii) Dean of Graduate Studies.
   (iii) Dean of Engineering.
   (iv) Chairman of the CE Department.

All of the universities we visited made every facility available to us and on several occasions disrupted the personal plans of faculty in order that they might meet us. Owing to the heavy commitments of the consultants and the ACAP deadline it was not possible for all of us to be at each university at the same time. We appreciate the cooperation of the universities in meeting our schedule and thank them for making our visits both pleasant and productive.

The Civil Engineering Discipline Group had not prepared a report based on the individual statements of the universities. We concentrated our initial attention, therefore, on the individual five year plans prepared by each university, and during our visits we sought to establish the basis for the stated plan. In this way we formed our own judgment about the strengths of the different civil engineering departments and the areas in which they are likely to be able to attract high quality students.

We have treated our assignment as being one of giving guidance on planning. The question of quality or accreditation we have only regarded as relevant to the extent that it has an impact on the plan to enter a new area of study or if a large growth of PhD students is anticipated relative to the current number of students.

A final and important step in our work has been to consider the Ontario system as a whole by putting the individual plans together and examining the results in the light of our own findings and judgements and in the context of the manpower report supplied to us by ACAP. At the conclusion of this examination we have made recommendations on the range of PhD enrolments during the 1973/78 period at individual universities. We have done this because it is required of us in our terms of reference and because we believe our judgement of this may be better than that of ACAP who would, we assume, have to make their own estimate in the absence of ours. However, we regard our recommendations as an integrated set of ideas and suggestions and would not wish to see the 'numbers' implemented without regard for the other items.

1.4 Structure of our Report

We believe that the context in which civil engineers are working has changed dramatically during recent years and is still in a state of flux. Our report starts with a short statement of our views on this matter because we consider that the planning of advanced education in civil engineering should reflect these changes.

We then provide some background information on graduate studies and enrolment in civil engineering and also discuss the question of academic standards.

The following section provides background information on the faculty involved in graduate studies, since this is the major resource on which a PhD plan relies.

There then follows a short section on each university which is intended to be a summary of the current and proposed PhD activity together with our own general impressions. In this section we also discuss the issue of size and our views on the relevance of this to PhD planning.

We have paid particular attention to the views of students, both past and present, who are after all the principal actors. A section is, therefore, devoted to their views.

The next section reviews the manpower forecasts, considers the role of PhD education and discusses the issues relating to a DEng degree.

In the next section on the five year plan that follows we draw together the various elements from previous sections and present our conclusions on the plan for the period 1973/78, viewing Ontario as a whole and then reflecting this in the individual university plans.

Finally we summarize our conclusions and recommendations.

Chapter 2

SCOPE OF CIVIL ENGINEERING EDUCATION

2.1 Introduction

Civil engineering is the oldest of the engineering professions and in Canada, building and civil engineering works account for about 20 percent of the gross national product. Undergraduate education in this subject covers the basic sciences, engineering core subjects common to all engineering branches, civil engineering core subjects (mainly structures, water resources, geotechnics and transportation), and some technical electives and social-humanistic subjects at the students' choice. Recently some specialty-oriented subjects in this curriculum have been replaced by interdisciplinary subjects relating to the planning, design, construction and operation of civil engineering facilities and systems in order to introduce students to the solution of some civil engineering problems in modern society.

With the exception of the University of Guelph, which mainly offers programmes in agricultural engineering, the universities mentioned above have graduated an increasing number of civil engineering students during the past 6 years (Table 1). These civil engineering graduates presently account for almost one-quarter of all engineering graduates and their number is unlikely to increase significantly during the next few years because the corresponding total undergraduate engineering enrolment is expected to remain roughly unchanged.

2.2 The Changing Climate

Civil engineering has traditionally been concerned with the details of how to design and construct the major works required by society. This has been reflected in the courses offered by universities at all levels that have been predominantly concerned with structural engineering, surveying, hydraulics and soil mechanics.

The traditional concern of building works for the lowest possible engineering cost has been increasingly challenged during recent years. Even before the 'environment' was fashionable, engineers were being challenged in respect of the aesthetics of their designs. Many so called 'engineering standards' have been challenged by administrations and politicians in recent times and engineers are having to justify decisions on fundamental issues such as whether to build something at all. More recently

Table 1

BACHELOR DEGREES GRANTED

(September - September)

University	1967 -68	1968 -69	1969 -70	1970 -71	1971 -72	1972 -73
Carleton	16	18	20	29	42	42
McMaster	11	5	9	16	17	26
Ottawa	7	19	16	22	28	24
Queen's	31	35	40	52	46	56
Toronto	55	52	62	60	70	59
Waterloo	48	48	69	118	121	114
Western	8	6	24	19	27	17
Windsor	8	13	21	17	22	14
TOTAL	184	196	261	333	373	352
Guelph (Agr. Eng.)	27	27	33	21	17	25

environmental issues have taken on greater significance and engineers at large have in many sectors been classed as the 'villains of the piece'.

In our judgement the slow and generally poor response of the engineering profession to this challenge is partly responsible for the decline in interest in engineering that was mentioned to us by administrators in several universities. However there are signs of change. The engineering profession is attempting to set the past record in a more accurate context and more important are pointing out that if we are to change our priorities with respect to the environmental situation then engineers will largely have to implement the new rules. Undergraduate programmes in many schools are becoming more flexible and broader based. Engineers are playing increasingly major roles in multidisciplinary teams dealing with water quality and resources, air pollution and control, transport and urban problems.

It is vitally important in our view that PhD programmes should reflect this changing emphasis with less stress on traditional areas, particularly structural engineering, and more stress on multidisciplinary education, environmental engineering, and transportation. Since many PhDs become tomorrow's teachers and others will hold key positions in industry and government it can be argued that changes should take place here before they occur in the undergraduate programmes.

The change in emphasis is further evidenced by the shift in employment of engineering doctorates, namely from universities to consulting engineering, industry and government.

Chapter 3

GRADUATE STUDIES AND ENROLMENT

3.1 General

Due to the broader base and interdisciplinary nature of many undergraduate curricula, the study of a civil engineering specialty in depth necessitates increasingly the undertaking of some graduate work. Graduate studies have also attracted more practicing engineers as a means of updating themselves and continuing education. As in the case of undergraduate studies, civil engineering master's and doctoral enrolments amount to approximately 25 percent and 20 percent, respectively, of the corresponding total engineering graduate enrolments at the master's and doctoral levels, respectively, on a full-time equivalent basis. Moreover, it is through the link with graduate studies that most university research is carried out, which has led to the establishment of important institutes and centres of excellence at various universities.

In civil engineering the largest specialty field for graduate studies is structural engineering, which accounts for about one-half of the total discipline. Studies in this specialty include such fields as applied mechanics, materials, planning, design and construction of structures. The second largest area is water resources engineering, which covers about 20 percent of civil engineering graduate work. This specialty includes hydraulic engineering, hydrology, sanitary and environmental engineering. The specialties of geotechnical engineering (soil and rock mechanics and foundations) and transportation engineering (planning, design and construction of transportation facilities and systems) each amount to about 15 percent of civil engineering graduate studies. It is of interest to note that these specialty percentages are about the same for students enrolled in master's and doctoral civil engineering programmes and also reflect the corresponding proportions of the total civil engineering faculty involved (see below).

While the number of full-time master's students has been declining in the last few years, there is a growing number of part-time master's students. This increase largely reflects the demand for courses by practicing engineers since the number of part-time master's degrees is still relatively small (Table 2). The proportion of part-time to full-time master's students enrolled presently exceeds 0.8 and may approach unity during the next 5 years. About one-half of the full-time students and about two-thirds of the part-time students obtained their

Table 2

MASTER'S STUDENTS ENROLMENT

Full-Time (Part-time)

University	1968-69	1969-70	1970-71	1971-72	1972-73
Carleton	13(14)	22(16)	25(15)	19(16)	15(13)
McMaster	18(6)	22(3)	24(6)	21(9)	16(23)
Ottawa	18(17)	33(14)	34(12)	26(23)	24(11)
Queen's	39(-)	36(-)	29(-)	31(-)	21(7)
Toronto	68(34)	74(49)	73(55)	68(88)	60(80)
Waterloo	53(10)	61(15)	50(15)	45(16)	51(18)
Western	11(1)	9(2)	12(6)	5(7)	4(6)
Windsor	23(11)	12(11)	9(12)	7(9)	6(6)
TOTAL ENROLLED	234(93)	269(110)	256(121)	222(168)	197(164)
Guelph (Agr. Eng., Hydr.)	18(-)	19(-)	18(4)	12(4)	10(3)
Degrees Awarded	107(-)	97(3)	123(5)	101(11)	125(33)
Guelph	6(-)	12(2)	10(1)	3(6)	5(3)

first degree in Canada, and roughly one-half of the remainder are landed immigrants from Asia (Table 3).

The number of students enrolled in doctoral programmes has not changed significantly during the last few years, and the number of part-time students is still relatively small (Table 4). Only about 20 percent of the full-time doctoral students obtained their first degree in Canada, which is a matter of some concern (Table 3). More than one-third of the remaining students are from Asia, while the others are mostly landed immigrants from other countries. On the other hand, about one-half of the part-time doctoral students are from Canada. Accordingly part-time doctoral programmes may be a good method of attracting more Canadian students to graduate work. Since there is a growing demand for part-time graduate studies by the engineering profession, it deserves full encouragement.

In recent years most of the graduate students have obtained their financial support from research grants and demonstrating assistantships (Table 5). The research grants are usually part of the personal operating grants of the supervising faculty members (see below) and are, thus, mainly federal or industrial support, while the demonstrating assistantships are usually paid by the universities and are, thus, mainly provincial support.

After completing their studies about one-half of the doctoral graduates were employed by universities, about one-quarter by industry while the remainder held government or research (including post-doctoral fellowships) positions in roughly equal proportions (Table 6). About one-half of these jobs were in Ontario.

We think that establishing an undergraduate curriculum forces the development of graduate research programmes in each university. However, because of the academic liberty until recently, the universities had very little control over these programmes, and this is one reason why now all universities are working on the same programmes. A few important exceptions exist, like the new graduate programme of Carleton-Ottawa and the exchange of professors between a few universities. The collaboration should be emphasized and be part of discussions between the deans of graduate studies and the heads of departments of the universities in order to develop coherent programmes. We would encourage collaboration between programmes and discipline areas

Table 3

GRADUATE STUDENT DATA

1972-73

LEVEL		IMMIGRATION STATUS	COUNTRY OF 1ST DEGREE					
			CANADA 1	USA 2	UK - AUST. 3	ASIA 4	OTHER 5	UNKNOWN 6
MASTER'S STUDENTS	F.T. 197	Canadian	94	1	1		1	1
		Landed Immigrant	4	1	9	35	21	
		Student Visa	1	1	1	16	7	
		Other	1			2		
	P.T. 164	Canadian	104			1	2	
		Landed Immigrant	2	1	8	25	18	
		Student Visa				3		
		Other						
DOCTORAL STUDENTS	F.T. 120	Canadian	22	1				
		Landed Immigrant	4	2	10	26	26	
		Student Visa	1		1	20	6	
		Other						
	P.T. 27	Canadian	13				1	
		Landed Immigrant				1	1	
		Student Visa			3	4	4	
		Other				1		

Table 4

DOCTORAL STUDENTS ENROLMENT

Full-Time (Part-Time)

University	1968-69	1969-70	1970-71	1971-72	1972-73
Carleton	4(4)	3(3)	3(3)	6(3)	7(3)
McMaster	7(-)	2(-)	4(-)	7(-)	6(-)
Ottawa	5(-)	4(-)	7(3)	17(3)	16(1)
Queen's	11(-)	13(-)	17(1)	18(1)	6(2)
Toronto	16(3)	22(4)	27(5)	21(10)	22(10)
Waterloo	56(9)	52(8)	48(13)	43(15)	43(9)
Western	6(1)	9(3)	10(3)	9(3)	8(2)
Windsor	8(2)	13(2)	19(1)	18(-)	12(-)
TOTAL ENROLLED	113(19)	118(20)	135(29)	139(35)	120(27)
Guelph (Agr. Eng., Hydr.)	2(1)	2(1)	2(1)	2(3)	3(2)
Degrees Awarded	11(6)	29(3)	18(1)	32(1)	30(5) + 7(Toronto)
Guelph	1	-	-	-	-
Post-Doct. Fellows	3	3	5	8	6

Table 5

GRADUATE STUDENTS (1)

SOURCES OF FINANCIAL SUPPORT

SOURCES	1968-69	1969-70	1970-71	1971-72	1972-73
NRC SCHOLARSHIPS *	17	22	21	21,	23
OTHER MAJOR SCHOLARSHIPS (GREATER THAN $2500)*	17	21	23	29	16
NRC BURSARIES *	5	9	10	7	6
ONTARIO GRADUATE FELLOWSHIPS *	11	15	17	11	7
CIDA (i.e. COMMONWEALTH SCHOLARS, COLOMBO PLAN, etc.)	16	19	24	22	15
FOREIGN GOVERNMENT SUPPORT	5	6	7	2	4
DEMONSTRATING ONLY	24	29	46	41	34
RESEARCH GRANT ONLY	90	84	82	71	43
DEMONSTRATING PLUS RESEARCH GRANT	90	107	137	129	150
SELF-SUPPORT	19	19	17	25	14
UNKNOWN	53	56	7	3	5
TOTAL	347	387	391	361	317

(1) Ph.D. and Master's Combined.

* With or Without Additional Earnings

NOTE: As of December 1. (For 1972-73, use October 1)
Total should equal total full-time enrolment.

Table 6

EMPLOYMENT SURVEY OF PHDS

1968-73

Employment	Ontario	Rest of Canada	Home Country	Other	Total
University	30	10	17	3	60
Industry	15	4	9	5	33
Government	4	-	8	-	12
Fellowship	8	2	-	1	11
Research (Other than Fellowship)	3	-	-	-	3
TOTAL	60	16	34	9	119

among the universities particularly in the areas of research, academic programmes, seminars, etc. An example of this is the present joint research seminar between Toronto, McMaster and Waterloo held annually.

Inside each university, more and more collaboration should be established between faculties and we are glad to see that this is becoming a common policy. However, we should watch ourselves not to give the impression to the graduate student that he will be a generalist ready to solve all the problems in the world. In our opinion, universities have the responsibility of forming specialists and a true generalist is a man who has worked as a specialist for many years and emerges because of personal qualifications.

We also found that too few Canadians are doing graduate work. We are wondering if we are not playing now the same role 'vis-a-vis' the underdeveloped countries as US did in the past. We are getting their best elements, we train them and we keep them as Canadians. We do believe that the whole philosophy of helping 'les pays en voie de developpement' should be revised. The important points are:- who is responsible for the cost (the Federal or the Provincial), and how to encourage them to go back to their country? Canada, as a whole, has a large responsibility in helping these countries.

To attract more Canadians in the graduate schools, many universities are accepting now, on a part-time basis, graduate students and in too few cases, the research being done in an outside laboratory is also accepted for thesis. We encourage the universities to increase their action in this direction. We also believe that a student generally be advised not to take more than two degrees at the same university.

As a whole, we feel that the enrolment in each university does not go above the capacity of the civil engineering department. Where the professional staff is mostly from outside Canada steps should be taken to integrate these professors in the Canadian life specially because most of the problems dealt with in civil engineering are closely related to the needs of the nation.

3.2 PhD Programme Requirements

The following table summarizes the PhD programme requirements of the universities offering PhDs in Civil Engineering. The table itself shows considerable variation between schools. Our visits revealed further differences not immediately apparent from the table concerned with the role of course work relative to the thesis and concerned with the quality of the students.

While most Ontario universities believe they are providing a PhD programme that lies between the research emphasis of the UK system and the course work emphasis of many US schools there are nevertheless a wide range of views on the objective of the course work. Some schools argue that the course work is required in support of the thesis research to provide the student with background in particular techniques or related fields. Other schools argue that a PhD must achieve excellence not only in his chosen field of specialist study but also in civil engineering as a whole. The latter view is often coupled with the statement that this approach will increase the employability of PhDs.

SUMMARY OF PhD PROGRAMME REQUIREMENTS

Carleton	MSc (usually from Carleton) or equivalent Written and oral comprehensive after 12 months 8 courses Thesis No language requirement 2 years 'presence'
Guelph	MSc Comprehensive No course requirement Thesis No language requirement 5 terms residence
McMaster	Usually has MSc Written and oral comprehensive within 2 years 4 courses Thesis No language requirement 2 years residence

Ottawa	Usually has MSc Written or oral comprehensive within 16 months 5 courses Thesis (can be written in French) Satisfactory technical knowledge of English and French 4 terms residence
Queen's	MSc Comprehensive within 1 year of presenting thesis 6 courses Thesis 1 language required 4 terms residence
Toronto	MSc and known to faculty Comprehensive (format flexible) Student must define major and 2 minors No formal course work requirement but typically 4-6 courses Thesis No language requirement 2 years residence
Waterloo	MSc plus industrial experience Comprehensive after 12-18 months Course work established by supervisor typically 4 courses Thesis No language requirement No residence requirement
Western Ontario	MSc (at Western or equivalent) Comprehensive within 12 months oral or written 6 courses (must also have 12 courses including MSc) Thesis 1 language required 1 year residence
Windsor	MSc (at Windsor or equivalent) Comprehensive at least 1 year before final oral 6 courses (must also have 12 courses including MSc)

Thesis
No language requirement
2 years residence

Note: (i) All course requirements expressed in units of term courses beyond MSc.
(ii) Residence expressed in terms of physical presence on campus not fees.

After meeting many students we are aware of some variation in their quality in so far as this can be measured by the way in which they express themselves verbally. A small proportion of the students we met were Canadian and these were generally of consistent quality. Most variation occurs in the landed immigrant and foreign students which is no doubt mainly related to the problem of assessing previous records. Against this, however, is the fact that most universities require these students to complete a master's course before proceeding to a PhD.

At this point in our report we merely wish to record the fact that these differences in approach exist between schools and their students because they will be relevant later when considering the manpower estimates and the role of PhDs over the next five years.

Chapter 4

FACULTY

After some increase in previous years the number of faculty members has remained essentially unchanged during the last 3 years (Table 7). About 15 percent of the faculty have part-time appointments, mainly for special graduate courses, and when given by practicing engineers they form a useful link with industry and government. About 80 percent of the full-time civil engineering staff hold PhD degrees and most of the remainder have master's degrees. Most of the PhD degrees have been obtained in roughly equal proportions from universities in Ontario, USA and Great Britain and only 10 percent elsewhere. Since only 3 PhDs (2 percent) have been obtained from other Canadian universities, the importance of Ontario universities in Canadian doctoral programmes for their own staff (as well as others) is evident.

The specialty fields of the civil engineering faculty are roughly divided as follows: structural engineering (50 percent), water resources engineering (20 percent), geotechnical engineering (15 percent) and transportation engineering (15 percent) which agrees with the corresponding proportions of graduate students enrolled in these fields. Personal operating grants from various agencies are held by about 70 percent of the full-time faculty members, and the average NRC grant amount to about $9000 per staff member last year (Table 8). Comparison of the number of grantees with the enrolment of graduate students indicates that on the average a grantee has currently about one PhD student plus two full-time master's students, which appears reasonable.

Most civil engineering faculty members combine teaching and research with some consulting and are, thus, registered professional engineers, which should help to bring practical engineering problems into the doctoral programme.

Table 7

FACULTY MEMBERS

Full-Time (Part-Time)

University	1968-69	1969-70	1970-71	1971-72	1972-73
Carleton	6(-)	7(-)	8(-)	8(-)	9(1)
McMaster	9(-)	9(3)	11(3)	13(2)	14(1)
Ottawa	7(-)	11(-)	12(1)	12(1)	13(1)
Queen's	18(-)	18(-)	18(-)	18(-)	18(-)
Toronto	21(-)	25(1)	26(1)	26(2)	26(2)
Waterloo	28(6)	30(6)	36(7)	33(11)	33(7)
Western	10(5)	12(4)	11(3)	10(3)	10(4)
Windsor	9(-)	9(-)	10(1)	10(1)	10(1)
TOTAL	108(11)	121(14)	132(16)	130(20)	133(17)
Guelph (Agr. Eng., Hydr.)	20(-)	17(-)	19(-)	22(-)	21(-)

Table 8

PERSONAL OPERATING GRANTS

(1972-73)

	National Research Council		Others*
University	Grantees	Amount ($1000)	Total ($1000)
Carleton	6	45	1
McMaster	9	91	165
Ottawa	9	49	5
Queen's	14	94	14
Toronto	15	110	70
Waterloo	30	298	181
Western	5	76	10
Windsor	8	78	3
TOTAL	96	841	449
Guelph (Agr. Eng., Hydr.)	9	57	61

*It should be noted that comparisons between universities are not reliable because of the considerable variation in the length of grants and the inclusion of equipment, computing, and other expenses in some cases.

Chapter 5

UNIVERSITY SYSTEM

5.1 Carleton University

During the fifteen years since the Faculty of Engineering was established, the development of undergraduate programmes received the major emphasis. The graduate programme in civil engineering, which was organized within the Division of Solid Mechanics and Structural Engineering, now falls mainly in the Department of Civil Engineering. Master's degrees in civil engineering have been awarded since 1963 and doctoral degrees since 1970.

The main graduate research areas are structural engineering, transportation planning and technology, and in cooperation with the Department of Geography and the University of Ottawa, geotechnical engineering. Structural engineering research has recently been focused on building design and construction in view of the proximity of the School of Architecture. Transportation engineering research involves cooperation between the civil and mechanical engineering disciplines and covers studies in the policy, planning, analysis and design of transportation systems.

Some additions are expected to be made to staff, but no significant additions to the facilities during the next five years, when the doctoral programme is expected to remain essentially at the present enrolment with a substantial portion of part-time students. The university does not intend to offer graduate programmes in water resources engineering.

The programme at Carleton is considerably enhanced by the close cooperation with the University of Ottawa.

5.2 University of Guelph

The university was established about ten years ago and its School of Engineering, which has just moved into a new building, offers programmes of study leading to the PhD degree in the areas of agricultural engineering and hydrology. Graduate studies and research in agricultural engineering are concerned with the properties of materials, processes and systems for the agricultural industry while in hydrology processes and systems for the optimum management of land and water resources are studied. Cooperation in the programmes is maintained with agricultural and science departments and, in the course of integrated aerial surveys, with the universities of McMaster, Toronto and Waterloo.

The number of full-time doctoral students is not expected to exceed 10 by 1980 and about equally divided between agricultural engineering and hydrology. Some additional agricultural engineering staff is contemplated to mount the only doctoral programme in this subject in Ontario by 1976.

5.3 McMaster University

The Faculty of Engineering was established fifteen years ago with programmes in structures and engineering mechanics, water resources, geotechnical engineering and transportation. For doctoral work in structures the specialization is in structural dynamics and earthquake engineering for which special experimental research facilities are available. In the water resources management field hydraulic and environmental research programmes are being carried out and close liaison has been developed with the Departments of Chemical Engineering and Geography and the Canada Centre of Inland Waters. The transportation and planning areas have similar liaison with the Department of Geography and have offered a master's programme, but there are no immediate plans for PhD work. Geotechnical research is in the area of soil properties with interdepartmental cooperation.

The doctoral programmes in civil engineering have emphasized the interdisciplinary character and industrial input, which have been enhanced by negotiated development grants in materials research and waste water treatment. A small increase in the number of doctoral students is expected during the next five years with little change in the number of staff and laboratory facilities.

5.4 University of Ottawa

The Department of Civil Engineering was formed ten years ago and has had master's and doctoral students since 1966. The Department supplies courses in water resources to Carleton University, which in turn gives courses in transportation and planning to students of the University of Ottawa. Cooperation with Carleton University has also led to a joint programme in geotechnical engineering.

The University of Ottawa is bilingual and an increasing number of graduate students are French speaking.

Doctoral graduate studies and research are carried out in the areas of structural engineering, water resources engineering and geotechnical engineering. Current structural engineering research includes dynamic and low temperature work, while hydraulics, hydrology and water treatment are investigated in the water resources area with the cooperation of related university and government departments. Geotechnical studies and research include soil and rock mechanics and permafrost, and support is obtained from the Geology Department and government departments.

With the expected increase in full- and part-time master's and doctoral enrolments some additional staff appointments are planned, but no additional laboratory facilities are envisaged in the next five years. The university does not intend to offer graduate programmes in transportation engineering.

The programme at the University of Ottawa is considerably enhanced by the close cooperation with Carleton University.

5.5 Queen's University

Doctoral work in engineering was developed about fifteen years ago. In civil engineering doctoral graduate studies and research are about equally divided between structural, hydraulic and geotechnical engineering. In hydraulic engineering the main emphasis is coastal engineering research for which the laboratory facilities are unique. Interdepartmental work has been increased by the formation of the Canadian Institute of Guided Transport some three years ago, and negotiations have begun to establish an interdisciplinary Centre for Resource Studies. Both activities could involve additional doctoral students and strengthen the programmes offered.

Doctoral students are expected to increase gradually in numbers during the next five years at roughly unchanged total staff and with some increase in laboratory facilities. Cooperation in graduate course offerings exists with the Royal Military College, which does not give doctoral degrees.

5.6 University of Toronto

The first PhD degree in civil engineering was conferred in 1960, and after a rapid increase in the number of graduate students, the enrolments in the master's and doctoral programmes have remained fairly constant in the last few years. Graduate studies and research are carried out in a number of main areas. In the structures and materials fields are the research groups of the Systems Building Centre concerned with the total planning, design and construction of structures and the Materials Research Group including biomedical work, both of which are set up on an interdepartmental basis.

The Institute of Environmental Sciences and Engineering carries out multidisciplinary research related to water resources and environmental protection, while the graduate programme in hydraulic engineering is under the Department of Mechanical Engineering. Research in the transportation area has been enhanced by the Joint Programme of Transportation Studies of the University of Toronto and York University on a multidisciplinary basis. In addition to geotechnical engineering research, the Department of Civil Engineering also supports graduate studies in surveying, jointly with the universities of Guelph, McMaster and Waterloo, and the new survey science programme at Erindale College.

The present enrolment in full- and part-time doctoral programmes is not expected to change appreciably during the next five years, and the same would apply to the laboratory facilities. However, the proportion of staff involved in graduate work is likely to increase somewhat.

5.7 University of Waterloo

The Faculty of Engineering began Canada's first cooperative programme of engineering education in 1957. Doctoral programmes are offered in solid mechanics, water resources and transportation and planning. The first group is by far the largest and includes structural engineering, applied mechanics, materials science and geotechnical engineering. This area of research has been further strengthened by a negotiated development grant in solid mechanics and by cooperation with the transportation group in the construction management field. Additionally, part-time and non-resident doctoral work is being developed in response to demand from industry.

There is a definite need for increased coordination between civil engineering, chemical engineering and geotechnics in research and academic programmes in the environmental area.

During the next five years the doctoral enrolment is expected to remain about the same as now, but with some increase in the proportion of part-time to full-time students. Further, some shift in the enrolment between the groups may occur with slightly larger faculty numbers and involving some reallocation of the resources between solid mechanics and other fields.

5.8 University of Western Ontario

Graduate studies and research in civil engineering were begun about ten years ago and doctoral programmes have been recently established in geotechnical engineering and industrial aerodynamics with its internationally known boundary layer wind tunnel laboratory. In addition there is a graduate programme in environmental engineering at the master's level on an interdepartmental basis.

Some increase in these activities is expected during the next five years together with the establishment of a doctoral programme in environmental engineering with the present faculty numbers, but laboratory facilities being slightly augmented. The university does not intend to offer graduate programmes in transportation engineering.

5.9 University of Windsor

Doctoral programmes in civil engineering were started in 1964. Graduate studies are now organized on a divisional basis with all departments collaborating, and some graduate courses were previously offered to the University of Western Ontario and vice versa. Graduate studies and research at the master's and doctoral levels are carried out in structural engineering, water resources and, to a limited extent, in geotechnical engineering. Several research projects have been carried out on an interdepartmental basis, and design-oriented research is being encouraged.

During the next five years doctoral programmes are expected to continue at present levels of enrolment, faculty and facilities in the area of structures, but water resources needs additional space. There is presently no intention to add graduate studies in transportation engineering.

The previous summaries, which are based on the information given by the universities and visits to them, indicate that the university system in Ontario provides a welcome diversity of civil engineering educational opportunities and doctoral programmes. The system provides a good quality coverage of the field and specialties without undue overlap on a regional basis.

The larger universities give doctoral programmes in all major specialties of civil engineering and they have expertise in most subdivisions of these specialties. Fortunately, these institutions are not so large that the educational quality would suffer and graduates would be deprived of close contact with the staff. This contact has attracted some faculty and doctoral students to the smaller universities. The latter have wisely restricted their graduate programmes and research activities to certain specialties in civil engineering and they rely for broader course offerings on regional cooperation, as was noted between Carleton and Ottawa particularly.

The problem of graduate study in a university is fundamental. When the decision is taken to introduce a new undergraduate discipline in any university, at the same time the decision is taken to introduce graduate studies in that discipline. If not, we feel that the teaching staff will be of a very poor quality. Another very important factor is the importance of good graduate work in a discipline if one wants to attract good undergraduate students in that new discipline.

As an example, a study conducted by the electrical engineering departments of Laval and Toronto has shown that in the years when we were doing good research in the power field, we had good undergraduates in the power field; otherwise, they were all taking the communication option. The effect of doing good research is felt even at the undergraduate level. Also, the decision is not to start or stop graduate work, but to accept or refuse a new discipline at the undergraduate level in a university.

By new discipline, we do not mean a new department, but simply an option within a department.

This reasoning could be developed as far as saying that, in the past, the decision to create a new independent university contained the obligation for the administrators to establish all disciplines. Furthermore, it was felt that the 'campus' or the 'buildings on the campus' were the true university. In the last few years, at least, the design and construction of buildings have taken so much time, that the executive board did not have time to think about education. The new restrictions and the lack of money might help them to become true university administrators. As a matter of fact, we felt during our visits that more collaboration should exist between universities and the 'outside world'. From our point of view, the two responsibilities of a university are to educate young people and do research work in order to get a better understanding of the existing world. Do we have to be on a campus to do both?

We believe that 'nuclei' of academic administrators should exist at some geographical points in Ontario with a few buildings, but that all available people, buildings and laboratories in the surroundings should and could be used. We were glad to see that more and more collaboration now exists between groups of professors and industrial and governmental laboratories. We feel, however, that this situation should be 'officialized' and steps being taken by university administrators in collaboration with industry and government to use more and more the existing facilities.

Ontario has the advantage of having very good industrial and governmental laboratories. We feel that the research work being done in these laboratories is, in many cases, equal if not superior to the university research. An example of such a collaboration is the agreement signed between the University of Quebec and the Research Institute of Hydro-Quebec.

5.10 The Question of Size

It has been argued that a doctoral programme can only be successful if it is located in a large school that is able to attract a substantial number of students at one time. It is suggested that there is a critical size below which, part of the value of the doctoral programme is lost because students cannot mutually exchange ideas and problems. Not surprisingly this argument is often expressed by faculty in large schools.

The counter view is that the ingredients for a worthwhile and productive doctorate consist of a good student, a good professor and a good problem. If this is so then the right combination may be found in any size university and critical size has no relevance.

There would seem to be some merit in both arguments. It does seem to be a general fact of life that larger universities attract and hold better quality faculty and consequently better students. The combination of ingredients may therefore occur more frequently in a large school. It is readily apparent, however, that there are outstanding individuals who have for a variety of reasons chosen to remain at a small university. In these circumstances a small school can also provide a good student, a good professor and a good problem.

The students themselves do not appear to be unduly concerned about the critical size issue. Those in the smaller schools appear to have a closer relationship and more discussion with their professor and his colleagues than those in big universities. Also the good students in the smaller schools appeared to be more aware of what was going on in their field in other universities in Canada and elsewhere. A large school, with a good reputation, can easily provide a security and a feeling of internal self dependence that can lead to a student forgetting that there is a world outside.

In our view, therefore, if a PhD degree is regarded as primarily a research based activity there is no a priori reason why a small school cannot provide as satisfactory an environment for a student as a big school. Size is not a sufficient criteria for judging whether a school can offer a PhD programme.

5.11 Financing Considerations

The system of financing university programmes is not within our terms of reference. However it would appear from our discussions that the weighting given doctoral programmes in the Basic Income Unit (BIU) system does have some influence on decisions made with respect to PhD candidates. This occurs in two ways.

Firstly because the BIU money is effectively a working fund for a school covering all aspects of the university's activities there is an inherent need to maintain a given level of BIUs from year to year. The university costs are not sensitive in the short term to the number of PhDs whereas the income from BIUs is much more sensitive because of the six times weighting. There develops, therefore, an inbuilt momentum to at least keep the PhD programme at current levels.

The second effect relates to the advice given to good students. Because undergraduates choose their university on a variety of criteria, including geographical location, there is a good probability of an excellent student studying at any university in the system. When this student seeks advice on graduate studies he should be able to get this without any form of bias. Frank discussions with faculty in Ontario reveal that this is very difficult to do because of the BIU implications. In this respect the problems are more difficult for smaller schools because the financial pressures are greater.

We would not wish to suggest that most students are getting biased or bad advice. We do think, however, that important discussions about the selection of a school for a student's PhD programme should take place without either party feeling there are financial losses or gains involved. This clearly is not the present situation.

Chapter 6

STUDENT VIEWS

6.1 Introduction

During the course of our visits to universities we discussed our assignment with 45 current and 10 past PhD students. We were particularly anxious to establish the reasons that lead to PhD work, the factors that influence the choice of university, the feelings among students about their job prospects and their views on the current content of PhD programmes.

6.2 Motivation

Table 9 (a) shows the reasons given by students for embarking on a PhD programme. Almost half had a basic interest in teaching, but of these a third would be returning to their home country and many were already in universities. Thus 30 percent of those we saw had an interest in teaching in Canada.

After teaching the prospects of a better job in industry and the personal challenge of a PhD programme were the most common reasons (18 and 17 percent respectively). Finally 14 percent of the students wanted to enter industrial or government research.

6.3 Choice of University

The general impression we obtained was that students are not particularly sophisticated about the way they choose a school. They naturally consider they made a rational choice and the 'best' but few students seem to have visited other schools prior to making their choice and many are ignorant of the facilities in their fields at other schools.

Nevertheless just over a quarter of the students chose a school because of the reputation of the faculty in a particular field. A fifth of the students stayed on because they did previous degrees at the same school. Sometimes this would be both the bachelor's and the master's. Often the PhD represented a continuation of the master's thesis research.

Just less than a fifth of the students made the choice on the basis of convenient geographical location (particularly relevant to the few part-time students) and the

Table 9

STUDENT MOTIVATION AND UNIVERSITY CHOICE

(a) Reasons Why Students Took PhD

Interest in teaching	30%
To obtain better job	18%
Personal challenge	17%
Interest in research	14%
Teaching in home country	14%
Other or no reason	7%
	100%

(b) Reasons Why Students Chose University for PhD

Reputation of faculty	26%
Did previous degree	20%
Because of location	18%
Not students decision	18%
Not known and other	18%
	100%

55 Students Interviewed

same number were placed by the grant-offering body - all foreign students.

6.4 Job Prospects

A surprising number of students were sanguine about the financial benefits of a PhD. They recognised that had the time spent on the PhD been spent in industry they would initially be financially better off. The compensation for this seemed to be the experience of taking the degree itself, the prospect of initially getting a job that would be more challenging, and a long run hope that the man with the PhD would go further all other things being equal.

Those students whose primary interest was teaching recognized that they might initially have to do something else given 'the current climate'. They rationalized this as probably being a good thing in the long run since they would see the outside world. Some looked to post-doctoral fellowships as an alternative in the short term.

We met a number of students who were writing their thesis and potentially on the job market. All of them had job offers, some challenging enough for them to leave before they would be completely finished. There was no evidence of great difficulty in obtaining jobs and the students, in all but two cases, felt the jobs were appropriate to their qualifications. It was not possible for us to make this judgement.

The two dissatisfied students had studied structures, and this is the only area of civil engineering where we sensed some softness in the job market.

6.5 Satisfaction with PhD Programme

Table 10 indicates the areas of dissatisfaction reflected in the students' views. Each student has one 'vote' in the table although in their discussions with us some students may have mentioned several items.

Bearing in mind that students were invited to criticize their programme in confidence, it is significant that well over a third indicated they were satisfied. It is interesting, however, to note that the past students were

Table 10

STUDENT RATING OF PHD PROGRAMME

SATISFACTION/DISSATISFACTION WITH PHD PROGRAMME

Satisfied	37%
Not enough technicians	14%
Too few courses	14%
Too many courses	11%
Facilities inadequate	11%
Other reasons	13%
	100%

Analysis of principal response given
by each of 55 students interviewed

far more critical than the current students.

Fourteen percent of the students felt that they could finish their research in a shorter period if there were more technician help available to them.

One quarter of the students were dissatisfied about the course work. However, some felt there were too many courses and some too few. The latter group includes those who felt there were too few of relevance. That is, they considered there were not enough courses offered of interest to them; a problem in some smaller schools.

Just over ten percent of the students criticized the lab space or library facilities. This was confined to two schools who we informed at the time of our visit.

Finally out of fairness to the students we should record some widespread concern about the ceiling of financial assistance available to PhD candidates, particularly those married with children. This does not lie within our terms of reference but the students voiced the opinion that this was a major factor leading to the very low proportion of Canadian PhD students.

Chapter 7

MANPOWER FORECASTS

7.1 Introduction

In common with other consulting groups we have received the Canadian Engineering Manpower Council (CEMC) report, Supply and Demand for Engineering Doctorates in Canada (July, 1973). As far as the supply side is concerned we have more detailed information available from the material submitted to us by ACAP and the universities. Insofar as it is possible to compare the two sources by using proportional factors on the gross figures included in the CEMC report the supply figures appear consistent. However, because of the greater detail available we have used our own figures rather than those in the CEMC report.

The demand side of the equation has presented us with more difficulties. The CEMC report either seriously under represents the civil engineering field or exposes a problem of gigantic proportions since it implies that supply exceeds demand by a factor of 18. Our own knowledge and findings suggest that in this area the CEMC report is not reliable and the report itself suggests this on page 158.

The employment survey of the civil engineering doctorates graduating in 1972-73 from Ontario universities indicates the results shown in Table 11.

These results seem to indicate that only two (less than 10 percent) have not found a situation, 22 are working in Ontario or in Canada, 10 have returned to their home country and 1 is working in some other country. It is very difficult to reconcile these results with those found in Tables 53 to 55 of the Canadian Engineering Manpower Council study entitled Supply and Demand for Engineering Doctorates in Canada. According to these tables, the demand of Civil PhDs is as follows:

1974	1
1975	2
1978	4

It is true that the authors (Thompson and Lapp) recommend that the "Canadian demand for engineering doctorates be reviewed regularly in the light of changing economic circumstances".

Table 11

EMPLOYMENT SURVEY OF DOCTORAL GRADUATES IN 1972-73

Total number of PhDs: 35

Employment:

	Ontario	Rest of Canada	Home Country	Other
University	3	2	6	
Industry	5	2	1	1
Government	2		3	
Community College or High School	1			
Fellowship	4			
Research	2			
Other	1			
Unemployed	(2)			
	18 (2)	4	10	1

We do think that the results presented in the report are too pessimistic and also quite dependent on the person who answered the questionnaire. In the case of Hydro-Quebec, it was turned over to the Head of Research who did not see at the time the needs for PhDs in Civil. However, now Hydro-Quebec is looking for specialists with PhDs or equivalent in Civil, Geology, Mechanical, etc.

It seems to us, and this is the responsibility of each university, that a better understanding between the industry and the university might help to improve the employment of PhDs.

Another important factor is the fact that a PhD in the future must be ready to accept doing work outside his own specialization. Our industry, until now, considers the engineer mostly as a 'Jack of all Trades', does not have, in many cases, the experience of hiring PhDs and is afraid of them. Ten years ago, we were not graduating any Civil PhDs and until recently, most of the graduates were hired by universities. More and more consultants and specialized industries will be looking for PhDs in civil engineering, if the university produces the right type of man.

Overall, we have not found the CEMC report of great assistance which was disappointing since we had been led to believe that it would be more helpful. We have noted the conclusions reached about the general situation in respect of the supply and demand for PhDs in engineering, and have used this background to our own assessment. Thus, the report indicates on page 22 that, on the average, the demand for engineering doctorates in Canada is likely to be roughly 20 percent smaller than the supply during the next five years.

We have been forced, however, to make some estimate of the likely demand for PhDs in civil engineering in order to guide our planning recommendations. This is not as sophisticated as the CEMC estimates in other fields, but bearing in mind that we will express the planning targets as ranges we believe it to be a more adequate basis than the figures available in the CEMC report.

In preparing our demand figures we have considered three separate areas:

(i) University requirements

(ii) Industrial, government and other employment

(iii) Foreign students.

7.2 University Requirements

As part of our visit at each university we sought to establish planned increases in the faculty of civil engineering departments. Originally this was to establish the background to changes in the programme emphasis. These figures have also proved useful in assessing the demand for PhDs in the universities themselves.

Only three of the schools indicated that there would be no likely changes over the next five years. The remaining schools identified 16 new appointments that would be made in this period due to existing vacancies, retirements and additions to cover new programme areas. Only four of these would be in structures since all schools indicated an intention to move staff resources away from traditional areas towards one or more of geotechnical, environmental engineering and transport.

It is the change of programme emphasis in civil engineering that leads to some growth in faculty when generally universities are expecting a fairly static period. The CEMC report suggests a negative requirement for faculty but this appears to overlook the fact that faculty are not hired and fired on a short term basis. Thus if undergraduates and master's students are to be exposed to new areas of emphasis in civil engineering some additional staff are inevitable.

In the past five years 25 percent of the Ontario PhDs graduating in civil engineering have been employed in universities in Ontario (Table 6). In addition a further 10 percent were employed in universities in the rest of Canada or the US. There will clearly be a substantial drop in the number employed in Ontario in future, our best estimate being that developed in the previous paragraph, and we have assumed the same proportional drop in those employed outside of Ontario.

Our assessment is that to provide 16 faculty members for Ontario and 5 for outside of Ontario the typical doctoral enrolment in civil engineering in the next five years needs to be 17 per year.

We are aware that this estimate ignores vacancies being filled from outside of Ontario but it also ignores other possible jobs in education but outside of the universities considered in the PhD review.

7.3 Consulting and Industrial Jobs

In the five years up to 1973 only 36 percent of the civil engineering PhDs were employed in consulting, industry, government and research (including post-doctoral fellowships). Many of these are employed in small consulting firms and we met some past PhDs who had established their own successful firms.

All of the universities we visited indicated an increasing number of requests from consultants, industry and government for PhD students. This was particularly evident in the fields of environmental engineering and transport. In several cases government needs have led to faculty in these areas being hired away from the universities. This has left significant gaps in their programmes and they are experiencing great difficulty in filling them because of the limited number of qualified people in these areas.

Bearing in mind that we found no widespread difficulty in PhDs obtaining employment, that the number obtaining industrial jobs has increased in recent years as jobs in universities have gradually decreased, and that there is an identifiable and increasing demand for PhDs in the new areas of civil engineering we consider that if enrolment levels were to stay at present levels the proportion obtaining jobs in industry would increase from 36 to 40 percent. That is a typical annual enrolment of 50 students.

7.4 Foreign Students

A major feature of civil engineering PhD programmes in Ontario has been the large proportion of foreign students - that is those returning to their home country (excluding landed immigrants). These have accounted for 28 percent of the output.

It is not for us to argue whether Ontario can afford this or not. We see no reason why it should decrease unless Ontario decides it should. In fact we could argue why it might increase and certainly most universities report that they are receiving an increasing number of foreign applications. We have assumed that the foreign proportion of current enrolment stays constant, which in fact leads to a slightly higher proportion of future enrolment. That is an annual enrolment of 33 students.

7.5 Total Enrolment Based on Demand

Taking these three classes of employment we obtain the following estimate of future demand, which we also compare with the current figures (1972-73) for full-time doctoral enrolment.

Table 12

ANNUAL PHD ENROLMENT

	Future		Current	
University Employment	17	(17%)	43	(36%)
Other Employment	50	(50%)	43	(36%)
Foreign Component	33	(33%)	34	(28%)
	100	(100%)	120	(100%)

This estimate is clearly no more than a broad guideline figure and we can see reasons why it might be both optimistically high and on the low side. Bearing in mind how we intend to use it, however, we believe it to be the best available to us and ACAP. Thus, our forecast indicates that the future civil engineering doctoral enrolment based on need should run about 20 percent below current levels in Ontario. It is of interest to note that this percentage agrees with the CEMC short-term forecast for engineering doctorates, in all fields in Canada and thereby supports our previously expressed doubts about the CEMC assessment of civil engineering manpower requirements.

7.6 Doctor of Engineering Programme

There is little doubt that the market for doctorates in engineering has changed markedly over the past several years. Where formerly most PhDs found employment in the university or research area, the present major market, particularly in such fields as the environmental and transportation area, is industry, governmental agencies and consulting firms. Two factors are of significance in light of the foregoing. The first reflects the nature of the training most applicable to this employment area; namely, that the student should be practically-oriented with a generally broad background in his field. Under most graduate school criteria, this would preclude the PhD degree. Secondly, there is an increasing interest in a part-time doctoral programme where the thesis work could be done on the job. The present PhD requirements, particularly relative to residence requirements, tend to preclude this in most institutions.

Thus, a Doctor of Engineering programme would have a modified residence requirement and a modified thesis requirement. A practically-oriented project or design, rather than a research thesis, could make this programme highly appealing and could provide a distinct service to the engineering community. The Doctor of Engineering degree should be considered in those universities where the suggestions above cannot be instituted under the present or modified PhD structure.

It is also our belief that the manpower report and manpower estimates presently being generated reflect the classical PhD and that if a Doctor of Engineering or equivalent programme was generated at the Ontario universities, the market for these persons would greatly increase. It is felt there would be considerable benefit to generating a manpower survey, based on the criteria discussed above. This would be more meaningful in light of present conditions and would be a better guide to the future plans of the various universities.

A question is frequently raised that the Doctor of Engineering degree results in a second-class citizen. We submit that when viewed in the professional engineering community this is not so and that the Doctor of Engineering represents the highest level of educational achievement among his colleagues. It might be noted that in many engineering circles the PhD degree is viewed as suspect in a practical, mission-oriented environment.

Chapter 8

FIVE-YEAR PLAN

8.1 Introduction

The civil engineering doctoral programmes during the next five years are expected by the discipline group to develop mainly within the presently established specialties of structural engineering, water resources, geotechnical and transportation engineering, although the relative importance of these will change.

Recent trends also indicate that interdisciplinary and industrial involvements in the doctoral programmes would increase in the near future so that the proportion of application-oriented and part-time doctoral programmes may become more important. In addition, there may be more collaboration and sharing of staff and physical facilities by universities on a regional level.

The above developments are likely to change the form of civil engineering doctoral programmes. On the other hand, the total faculty and physical facilities in the university system will remain essentially at their present size due to financial restraints, with a possible maximum increase of about 10 percent in staff and facilities, which should be sufficient for the civil engineering doctoral programmes, during the next five years.

It should be recognized that some flexibility should be maintained to take account of:

(a) addition of new faculty in specific programme areas

(b) loss of faculty in programme areas

(c) introduction of innovative programmes such as Doctor of Engineering, part-time programmes, etc.

The future five-year enrolment of doctoral students, as envisaged by the discipline group in civil engineering, shows a 10 percent drop from the previous five-year period when expressed in terms of full-time equivalent students (Table 13). This decrease represents the adjustment from a moderate over-supply of doctoral students in the last few years and the reduced number of foreign students without landed immigrant status.

An assessment of the desirable enrolment in doctoral programmes should be based mainly on academic quality and socio-economic factors. While it is generally agreed that

Table 13

ESTIMATED DOCTORAL ENROLMENT

(Full-Time Equivalents)

University	1973 -74	1974 -75	1975 -76	1976 -77	1977 -78	Recommended 5-Year Range
Carleton	7	6	6	6	6	5- 6
McMaster	7	9	10	11	12	6-10
Ottawa	15	17	18	21	21	13-17
Queen's	6	8	9	10	10	5- 8
Toronto	25	27	27	27	27	20-24
Waterloo	34	29	33	32	32	26-31
Western	10	11	12	13	15	9-12
Windsor	8	7	6	6	6	5- 7
TOTAL	112	114	121	126	129	
Recommended Total Range	90 -100	90 -100	90 -100	95 -105	95 -105	
Guelph (Agr. Eng., Hydr.)	4	4	5	7	8	4- 7

everyone should be educated to the limit of his personal ability and interest, it has been found that good students in doctoral programmes should have at least upper second class (high B) or upper 25 percent standing in their graduating class. Such admission standards usually ensure that a full-time doctoral programme with good thesis is completed within 3 to 4 years. Moreover, a qualified professor working with good students on a good topic should have no difficulty in obtaining sufficient financial support and writing a paper on their research as contribution to knowledge.

As mentioned before, the importance of the master's degree is growing as a basis for professional work such as design and development in the civil engineering specialties. In some of these, for instance geotechnical and transportation engineering, a master's degree is generally considered to be the minimum entry qualification, and a doctoral degree is often desired for more responsible positions. With increasing sophistication and wider socio-economic impact of civil engineering works the doctoral degree may soon become as frequent as the master's degree is to-day. The doctoral degree may also become an essential qualification not only for teaching and research as presently, but also for specialized consulting engineering and some design and development work in industry and government.

8.2 Factors Considered

The following factors were considered in developing our recommendations on PhD enrolments for the next five years.

1. The universities' own estimates.
2. The CEMC Report.
3. Our own manpower estimates.
4. The fields of study.

Items 1, 2 and 3 are dealt with in other parts of this report. Item 4 is discussed below.

8.3 The Fields of Study

During our visits we asked the universities to assess the likely fields in which PhD students would be studying. This is clearly a stage more difficult than estimating the total enrolment but a general indication is important in judging the five-year plan.

The results for the eight major schools together were as follows:

Table 14

FIELDS OF DOCTORAL STUDIES

Field	Number of PhDs Awarded 1973-78	% 1973-78	% Recent Years
Geotechnical	22	16	15
Structures	73	50	50
Water Resources	36	25	20
Transport	13	9	15
	144	100	100

The universities generally recognized the increased demand for water resource and transport graduates. Several mentioned the difficulty of holding students (and staff) in these fields because of the pressing demands of government and consultants. It would be wrong to educate PhDs in structures just because those students are available.

Bearing in mind the changing role of the engineer, the existing and likely future employment needs we consider that the balance of study between fields needs shifting. Even the universities' own demands reflect this because of the 16 new faculty that were identified only 25 percent were in structures. At the end of the five-year period we believe the proportions should look more like:

Geotechnical	15%
Structures	30%
Water Resources	30%
Transport	25%
	100%

For planning purposes we have used average figures for the period as follows:

Geotechnical	15%
Structures	40%
Water Resources	25%
Transport	20%
	100%

8.4 Enrolment Targets

In preparing enrolment targets our manpower estimate has been used as a control together with the distribution between fields given in the previous section.

The effect of these two factors is to reduce enrolment levels at all schools compared with their own forecasts but more so at schools that are predominant in the traditional fields of civil engineering and less so at schools offering programmes in environmental engineering and transport.

The exceptions to this was recognition of the unique facilities available at Western for boundary layer wind tunnel work, at McMaster for earthquake engineering and Guelph for agricultural engineering. In these three cases, and for the specific fields mentioned, an add back was made to the totals in recognition of the wider geographic draw of these schools and the high demand for their graduates.

The last column of Table 13 gives the recommended enrolment ranges for each university, and the recommended system total ranges are shown near the bottom of that Table.

The effect of our recommendations is approximately a 20 percent decrease in the planned enrolment. This reduction agrees with the general conclusion from the CEMC Report, in respect to all engineering doctorates. The indications from our visits were that our recommendations for 1973/74 are likely to correspond closely with the number of students which universities were able to attract for this academic year. This smaller decrease would in any case be a reasonable transition in the first year.

So long as the total doctoral enrolment falls roughly within the recommended range, the distribution can be reviewed by the universities in a few years time, and this would ensure that students can have a free choice of the university for their doctoral work. However, no numerical recommendations are made for the distribution of the doctoral enrolments between the various civil engineering specialties, since this should be left to the universities' decision. In this way they will have the freedom to change emphasis of the specialties in their doctoral programme as future demands require.

8.5 Fields Offered by Universities

In the current climate and if our recommendations on enrolment levels are accepted we do not think that any of the schools should offer PhD programmes in new fields. That is, where transport and environmental engineering programmes are not available new programmes should not be added during the five-year period.

Any school that feels this is unduly restrictive should in our view have to make the case for its new programme to a group similar to the Discipline Group established to guide our work.

Since all currently offered civil engineering doctoral programmes in the universities fulfil a demonstrated need, it is recommended that any university which presently offers such programmes continue these unless that university desires otherwise.

Chapter 9

CONCLUSIONS AND RECOMMENDATIONS

1. PhD education should reflect the changing role of the engineer in society.

2. The role of PhD education and particularly the research versus course content issue needs to be recognized.

3. There is a case for more consistent requirement of acceptance for PhD students between universities. The concept of an external examiner on acceptance committees (as well as thesis committees) is worthy of examination by the Discipline Group. This would help to reduce the distrust large schools have of small schools and vice-versa.

4. There is no *a priori* reason why a small school cannot provide as satisfactory an environment for a PhD student as a big school.

5. The BIU system needs examination in terms of its effect on PhD programmes. One proposal would be to collapse the PhD BIUs into the undergraduate BIUs increasing the value of the latter. This would be based on a typical year's enrolment of PhDs. This reduces the financial conflict but still recognizes that the major running costs continue whether a PhD is enrolled or not.

6. Student satisfaction with existing PhD programmes is generally good. Most schools could help their students more by reviewing their counselling methods.

7. Reviewing all the available information suggests that the *need* for civil engineering PhDs will decline by about 20 percent compared with present levels of enrolment.

8. There is a case for changing the emphasis in the fields of study increasing the proportion of non-structural engineering students.

9. The annual enrolment ranges should lie in the ranges recommended in Table 13 above for each university.

10. There should be no additions nor reductions to the range of PhD programmes offered by any school.

11. Full encouragement should be given to part-time

doctoral programmes, to interdisciplinary and application-oriented programmes and industrial involvement in them.

12. A Doctor of Engineering degree programme should be established having modified residence and thesis requirements to facilitate part-time studies and research under an industrial environment.

APPENDIX B

DISCIPLINE GROUP RESPONSE

B-1

QUEEN'S UNIVERSITY
KINGSTON, ONTARIO

November 14, 1973

Professor M.A. Preston,
Executive Vice-Chairman,
A.C.A.P.,
Council of Ontario Universities,
102 Bloor St. West,
Toronto 181, M5S 1M8
Ontario.

Re: Civil Discipline Group Response

Dear Professor Preston:

I enclose herewith the Civil Discipline Group Response to the Civil Assessors' Report to A.C.A.P.

Consenting to the transmittal of this response are the following:

A. Brebner, Head, Queen's University at Kingston
A.G. Davenport, Chairman, Western University
D.A. Kasianchuk, Chairman, Carleton University
J.B. Kennedy, Head, University of Windsor
T.C. Kenney, Chairman, University of Toronto
D.R. Pattie, Acting Director, University of Guelph
A.A. Smith, Chairman, McMaster University
T.H. Topper, Chairman, Waterloo University
R. Townsend, Acting Chairman, Ottawa University

Yours sincerely,

Arthur Brebner.

Dr. A. Brebner,
Chairman,
Civil Discipline Group.

AB:hw
enc.

QUEEN'S UNIVERSITY
KINGSTON, ONTARIO

RESPONSE OF CIVIL ENGINEERING DISCIPLINE GROUP TO CIVIL ASSESSORS' REPORT TO A.C.A.P.

1. It is the opinion of the Civil Engineering Discipline Group that the Civil Engineering Doctoral Planning Assessment Report is, in the main, an acceptable one in view of its fairness and reasonably workable recommendations contained in Chapter 9 of the Report.

2. Despite the fact that the consultants state ...... "we have formed our own judgement about the strengths of the different civil engineering departments and the areas in which they are likely to be able to attract high quality students" (Page A5), the consultants decline to address themselves to the question of quality in the planning function in their conclusions and recommendations. It might be inferred that all existing programmes are acceptable from a quality viewpoint and that the consultants have discharged their responsibilities under their terms of reference. However, to clear up this issue the consultants could be well asked to clarify this point since they, in the view of the Civil Group, did not apparently seize their unique opportunity to make quality judgements. Such an appendix

which documents the sundry strengths and weaknesses, if they exist, could well increase the value to those on whom the responsibility for planning ultimately rests.

3. It is refreshing to see that the Report recognizes the role to be played in Ph.D. work by the so-called small university since this is contrary in many respects to the concepts expressed in the Ring of Iron Report, concepts which in many ways led to the setting up of the present study. The Civil Group applauds this recognition and whole-heartedly endorses this view (Recommendation 4, page A52).

4. The Report plainly points out the unreliability of the Lapp-Thompson CEMC figures - a point of view echoed even more strongly by the Civil Discipline Group since the Lapp-Thompson demand survey of the Civil field was woefully poor in that the authors of the CEMC report appear to neglect the fact that Civil Engineering is a profession, not an Industry. Thus, considering the uncertainties of manpower needs and the highly questionable Lapp-Thompson data for Civil Engineering, the Civil Group questions whether the recommendation of a 20% reduction is sufficiently significant to warrant control mechanisms.

The current energy crisis, the ever-changing political views on such things as mass transportation (with their resulting interaction on the sociological and climatological surroundings) for instance, may well increase the demand for Ph.D.'s. The Report treats this aspect of future trends very sketchily indeed as does the CEMC Report.

Enrollment limits should only be imposed if there is a serious over-production of Ph.D. students. This is obviously not the case in Civil Engineering.

5. The recommendation regarding the D.Eng. programme may well be a viable one and will be given serious study --- but it is not the only solution. The Civil Group feels that an equally viable solution to the attraction of more Canadians already in the profession back to a Ph.D. or D.Eng. environment could be achieved by similar tactics as those employed by M.R.C. - namely in making the rates of emolument roughly comparable to that of interns or junior engineers. For the same expenditures of monies, doubling the emolument to Canadian professionals would both enhance the quality and reduce the number of candidates if that is felt to be the desirable goal. In this connection the Civil Group strongly endorses the views expressed by the Assessors on Page A38 regarding emoluments. The ceilings imposed by O.C.G.S. are a major factor inhibiting the young Canadian professional from pursuing Ph.D. or D.Eng. work. The views of the Assessors could well be transmitted to N.R.C. and other granting agencies.

6. The liaison between various areas of the University at the Ph.D. level is given scant reference in the report as is evidenced by the lack of mention of such co-operative efforts at most Ontario Universities, such as co-operation between Civil, Chemical and Environmental, between Civil, Geophysics or Biology and Geotechnical, and between Civil, Mechanical and Mechanics, etc.

7. The Civil Group is extremely disappointed that the various sources of Civil funding were not clearly shown on Table 8 (Page A24) but confined to NRC sources. All funding information supplied to A.C.A.P. was seemingly not passed to the consultants by the A.C.A.P. secretariat despite reminders to that latter body of the fundamental importance of non-NRC funding in Civil Ph.D. work. The consultant's caveat on Table 8 is insufficient to clarify the totally erroneous impressions such figures give.

8. In conclusion, with the previous comments and reservations, the Civil Discipline Group is pleased by the air of sanity with which the Assessors brought out their Report.

Arthur Brebner

Dr. Arthur Brebner,
Chairman,
Civil Discipline Group.

November 14, 1973.

APPENDIX C

UNIVERSITY COMMENTS

Comments appear from Carleton, Guelph, McMaster, Ottawa, Queen's, Toronto, Waterloo, Western Ontario and Windsor.

CARLETON UNIVERSITY

RESPONSE TO FOUR ACAP ASSESSMENTS ON ENGINEERING

Introduction

Carleton takes the view that groups of disciplines should be evaluated before a clear picture of the situation within a single discipline can be obtained. Reports on any one component considered in isolation could lead to an erroneous judgement and unwise and precipitate action. Three consultants' final assessment reports have now been received for engineering disciplines in which Carleton is actively involved: Civil Engineering, Electrical Engineering, and Mechanical and Aeronautical Engineering. A fourth report deals with Metallurgical and Materials Engineering, of less direct concern to Carleton, while a fifth report, not yet received, will deal with Chemical Engineering, a discipline not represented at Carleton.

This response will address itself to the four reports which have been received and examined to date. We may wish to add further comments when the fifth report has been studied.

We sense a good deal of unanimity on a number of fundamental questions among the fifteen consultants involved in the four reports so far received, a communality of viewpoint which we share and endorse. We believe that Engineering has been most fortunate in having the assessments carried out by a group of consultants whose international stature, valued judgement and perspective give authority and credibility to their studies and reports. In general then we accept their findings and subscribe to their recommendations with only a few exceptions to be noted later.

In this response we shall deal first with those matters which we believe to be basic and general in nature and leave until the end our views on specific points raised in individual reports.

Matters of a Fundamental or General Nature

1) Control of Student Numbers:

The four reports are unanimous in their opinion that previous estimates of the demand for engineers with doctoral degrees, notably those in the Lapp Report of 1970 and the report for CEMC of 1973, have erred seriously on the low side. They point out that there is no evidence of difficulty in obtaining jobs by students close to graduation, nor do they foresee difficulties in the future except for those which normally occur in highly specialized areas.

The consultants reject the notion of quotas applied to departments to control student numbers, in part because the demand seems likely to exceed the supply than the reverse, making quotas unnecessary, but in the main because they feel that other means of control are to be preferred. The report on Electrical Engineering puts it this way: "The number of doctorates granted in electrical engineering (should) be determined by:

(i) availability of qualified students

(ii) maintenance of adequate standards by the universities, and

(iii) the existing capacity (staff and facilities) of the universities for giving adequate training." The Mechanical consultants refer to emerging natural controls and go on to say: "We would wish the resources of the present system, which are predicated principally on undergraduate requirements, the market demands, the quality of the programme and the good judgement of the departments to determine the total number within the system."

Carleton subscribes fully to these views. We believe that rather than through centrally imposed quotas or limitations the universities individually should control numbers by restricting admission to students showing high promise and by maintaining adquate standards. The latter together with the market demand will provide an adequate control. We would be prepared to support the development and adoption of an evaluation scheme, such as the scholastic index used at Carleton, which can be applied across all disciplines and which could be used in the monitoring of admission standards which we believe should be a matter between a university and OCGS. We believe, however, that the interpretation of these standards for individual student cases should be left to the informed judgement of the university concerned.

2) Quality of Existing Programmes, Suggestions for Change:

From their comments on the quality of the Ph.D. programmes for the system generally, it is clear that the consultants believe it to be quite acceptable. The Civil consultants point out that "the system provides a good quality coverage of the field and specialties without undue overlap on a regional basis." Comments on individual universities draw attention to departures from the norm in both directions.

A common theme running through the reports is the need for greater flexibility in the future. The Metallurgical and Materials consultants state it this way: "As Canadian industry becomes more sophisticated and has to rely on more advanced technologies, it will have to learn how to fully utilize the talents and skills of Ph.D. graduates and the universities will have to learn how to develop Ph.D. programmes which produce imaginative engineers capable of responding to these new opportunities." These consultants also recommend that programmes be so designed as to permit graduates from other specialties to change specialties as they commence Ph.D. work.

The consultants also show a degree of consistency regarding the need to shift the emphasis in Ph.D. programmes to meet the situation of the seventies. The Electrical consultants state it this way: "The education of Ph.D. students in areas of national need is a more efficient use of resources than is a random choice of fields followed by a period of retraining." In relating it to their field, the Civil consultants state that there should be "less stress on traditional areas, particularly structural engineering, and more stress on multidisciplinary education, environmental engineering, and transportation." The Mechanical consultants recommend a greater emphasis on production engineering and design.

Close contact between universities and industry is felt to be important by all the consultants and individual universities have been singled out for commendation where this contact is regarded as exemplary while others have been asked to improve in this respect.

Once again Carleton accepts the findings of the consultants on the quality of the existing programmes and their views on the nature of Ph.D. programmes required for the immediate future. We feel that we have already made considerable progress toward achieving the desirable objectives set out by the consultants and that we have received adequate recognition for this in their reports.

3) Critical Size:

The Engineering consultants are far less concerned about the concept of critical size than the consultants who carried out some of the earlier planning assessments, and show as much concern for the disadvantages of "bigness" as of "smallness." The Engineering consultants place their primary emphasis on the quality of the student and of the faculty rather than on size, a view which we heartily endorse.

The Mechanical consultants take the strongest stand against the notion of critical size. While admitting the advantages enjoyed by a large group, they go on to express their view that "a drawback to the large group is the difficulty of adapting to change" and further that "the groups in the smaller departments often displayed an original point of view and a willingness to adapt to change that was not apparent in the larger and longer established departments." They found more cross linkages between departments and a greater tendency to establish outside contacts with government and industry in the smaller faculties. They conclude: "In our view no creative group, and no capable individual within such a group should be denied support because it is small." The Civil consultants echo these views: "Size is not a sufficient criterion for judging whether a school can offer a Ph.D. programme" and also "there is no a priori reason why a small school cannot provide as satisfactory an environment for the student as a large school."

The Electrical and Metallurgical and Materials consultants are not as definite on the matter of critical size as the Civil and Mechanical consultants. The Electrical consultants felt that a desirable size for a department fell in the range from 10 to 20 faculty with from 10 to 20 students enrolled but expressed the view that "high standards of excellence with emphasis on quality rather than quantity will pay off in the long run." The Metallurgical and Materials consultants draw attention to the contrast between the British approach to Ph.D. education centered around the thesis and requiring only one good faculty member and the American view that a department needs to be sufficiently large to provide a proper range of courses because of the importance given to course work in the American approach. The consultants themselves took the position that students should be taught by members of the basic science departments as well as by Engineering faculty members and that the critical size of the core depends a great deal on the strengths in related disciplines. The latter factor seems to have been ignored by some of the consultants who assessed the non-Engineering disciplines.

As indicated above, Carleton is fully in agreement with the position on critical size taken by the Engineering consultants and does not support the views of the Chemistry or Economics consultants nor ACAP's views on this matter.

4) Proportion of Foreign Students:

All four of the reports under review make reference to the enrolment of foreign students in the graduate programmes at Ontario Universities.

The Electrical consultants noted that the percentage of doctoral students with first degrees from Canadian universities was consistently in the range from 47 to 51 over the past five years. They believe an ideal mix should involve students with a variety of backgrounds coming from various universities and should include some students from foreign countries. The latter they feel should be in the minority and they suggest 25% as an appropriate proportion. The Civil consultants expressed concern also at the low percentage of full-time Ph.D. students who had obtained their first degree in Canada but remarked also that the percentage was much higher for part-time students and suggested that part-time studies should be encouraged.

The Mechanical consultants, while noting a similar proportion of non-Canadian first degree students to those mentioned above concluded that we cannot count on Canadian undergraduate schools to provide candidates in sufficient numbers and that we must continue to rely on students from abroad. The latter would likely decrease in number in the future due to recent policy changes with respect to immigration and financial support for students without landed immigrant status. They suggest that support for such students should come from appropriate federal agencies such as CIDA.

The Metallurgical and Materials consultants find that "Canadian industry unable to fill its vacancies with Canadian graduates of Canadian origin has preferred to import graduates from British or Australian origin rather than employ Canadians of Asian origin." They recommend an intensification of efforts to recruit a larger proportion of Ph.D. students from the graduates of Canadian universities.

Carleton is in agreement with the consultants concerning the desirability of having a mix of students from different universities in Canada and from foreign countries and in having a reasonable balance between Canadian and non-Canadian first degree holders. The problem of foreign students is usually expressed as one of controlling their number. We believe that the recent immigration and financial restrictions imposed on this group is likely to overshoot the mark and the problem in the future may well be one of too few rather than too many foreign students. A more serious problem is that of too few graduates of Canadian schools embarking on Ph.D. work.

Comments on Some Specific Matters

In this section we wish to deal with some specific issues raised in individual assessment reports.

1) Civil Engineering Doctoral Planning Assessment:

The references to Carleton University throughout this report are generally favourable and on the whole we like their conclusions and recommendations. There are, however, one or two points we wish to question.

In Recommendation 3 the consultants suggest "there is a case for more consistent requirement of acceptance for Ph.D. students between universities We are uncertain as to the meaning of this since it is not discussed in the body of the report. We have expressed the view earlier that there should be a system, such as Carleton's scholastic index, for evaluating students across all disciplines, and that OCGS might monitor standards of admission generally. We do not see the need for an external person on acceptance committees but continue to support the position that there should be external examiners on thesis committees.

We cannot accept the proposal in Recommendation 5 concerning the collapsing of the Ph.D. B.I.U.'s into the undergraduate B.I.U.'s although we can support the objective. We believe that a major re-examination of the formula for providing operating funds to the universities is called for, not just minor adjustments to B.I.U. weightings.

We do not see the necessity for the further proliferation of degree designations which would result from the introduction of the Doctor of Engineering Degree included in Recommendation 12. We support fully the consultants' concept of a range of possibilities for a doctoral thesis, from the mathematical or theoretical at one end to the design or application-orientated at the other end, but we believe the requirements for the Ph.D. should be flexible enough to permit this as is the case at Carleton.

2) Report on Doctoral Programmes in Electrical Engineering in Ontario Universities.

For the purposes of assessment and reporting, the consultants have combined Carleton's departments of Electronics and Materials Engineering and Systems Engineering under the discipline title of 'Electrical Engineering.' Their comments, conclusions and recommendations apply uniformly to our two departments. We regard this report as a highly competent and thorough piece of work. The analysis in the earlier sections prior to the evaluation of departments gives to the whole a degree of credibility that is probably unique in such reports.

Carleton University has received a uniformly favourable assessment in Electrical Engineering. The Ph.D. programmes in both departments are considered to be "strong." The interaction of Carleton with laboratories and firms in the Ottawa area is described as a "model" while our programmes are praised as having "unusually high contemporary relevance."

We intend to pursue our proposed five-year plan for the graduate programme in Electrical Engineering; we believe that our present organization into the two departments of Electronics and Materials Engineering and Systems Engineering is the most appropriate and effective for our purposes and intend to maintain this organization.

We have noted the general recommendation that only students showing high promise for graduate work should be accepted into the Ph.D. programme. We endorse this recommendation.

We plan to aim for the small growth in graduate student numbers proposed in the five-year plan, but note that in the consultants' view this growth is modest. We shall allow ourselves to be responsive to the applications which we receive from well-qualified students. We expect that our growth will be limited to a natural and non-excessive rate by the limited availability of good applicants.

We believe that it is possible to increase the scale and effectiveness of our associations with laboratories and firms in the Ottawa area and shall endeavour to exploit further such interactions.

The recommendation that greater use be made of graduate courses given at the University of Ottawa is accepted. The establishment of a close working relationship over the last two-year period has made the sharing of course offerings and facilities a natural outcome which it is intended to exploit.

We accept the report of the ACAP consultants without reservation. We consider the assessment to have been fairly and thoroughly done and believe that the report as a whole will be of considerable benefit to the Electrical Engineering profession in Ontario and Canada.

3) Report of the Mechanical Engineering Consultants:

We accept the ACAP consultants' report on Mechanical (and Aeronautical) Engineering without reservation. We consider it to be a valuable, authoritative, well reasoned document. The report is thoroughly credible because of the competence and international stature of the consultant team and the excellent overview they provide.

We accept the consultants' argument that, because "the developing market could easily absorb double the rate of output (presently about 30 Ph.D.'s/year in Ontario) during the next five years" and because of the serious undersupply of qualified candidates, assigned quotas for the Ontario system would be meaningless.

We agree that adequate capacity and quality exists within the department and that decisions about specific research areas should be made within the individual universities. We accept the criticism that excessive effort has been devoted to "traditional and classical areas of research" and that our efforts should continue to be re-directed towards research more pertinent to the practice of Mechanical and Aeronautical Engineering. We agree that the relevance of the research work would be enhanced if support were made more dependent on contracts from high technology industry and appropriate federal government departments.

We intend to pursue our proposed five-year plan and strengthen our contacts with industrial and government laboratories. We will explore the possibility of establishing an industrial research institute (or an office of industrial research) since these institutes are noted as having a highly beneficial effect on the research of the faculty and graduate students.

We applaud the recommendation that a good Ph.D. programme should provide breadth by means of well balanced course work and depth by means of a thesis involving substantial research on a specific and topical engineering problem. Doctoral graduates from such a balanced educational programme will be able to move into industry and tackle problem solving on a broad front.

Conclusion

We hope that it will be clear from the foregoing that we find the reports generally quite acceptable and can endorse all their major conclusions and recommendations. We regard the specific points on which we disagree with the consultants to be minor in comparison to the aggregate of the issues on which we agree.

G. R. Love
November 12, 1973

UNIVERSITY OF GUELPH

Comments on Consultants' Report

Civil Engineering Doctoral Planning Assessment

The University of Guelph records its favourable reaction in general to this report; but we make the following specific comments.

The 5-year range for doctoral enrolment, recommended as 4 to 7 in Table 13 page A-47 seems appropriate for Agricultural Engineering and for those students enrolled in the Hydrology program who may be registered in Engineering. It should be emphasized that the Hydrology program at the University of Guelph is an interdepartmental program administered by an interdepartmental committee. It is NOT a program of the School of Engineering. Students enrolled in the program may come from one of a number of departments. Hydrology is of such vital public interest that enrolments may well burgeon within the next five years. The University would expect to do its best to meet the public interest.

The participation of our School of Engineering in the Hydrology program indicates the School's traditional focus on environmental matters. Concern for the environment is an important consideration in our graduate program in Agricultural Engineering. The program is interdisciplinary in character (involving not only civil and mechanical engineering but also major input from the biological sciences); it is obviously application-oriented, and linked very closely with the various aspects of the agricultural industry (see recommendation 11). In such a context the interest of the consultants in establishing PhD research off-campus in an external laboratory would pose no major problem for the University of Guelph.

We note with approval the consultants' position regarding size (section 5.10). The close relationships between graduate student and instructors seem to us natural and inevitable, and proved by experience. We are less sure of the validity of the claim made by those who advocate the concept of critical size. The "recipe" of the consultants, calling for a good student, a good professor, and a good problem, we find attractive.

We concur in the consultants' views on the changing role of the engineer in society (section 2.2). It would appear that provision should be made for engineering students to become informed on matters pertaining to social policy.

With regard to manpower forecasts we are disturbed, even alarmed, when reading the consultants' comments (section 7.1) on "demand" as presented in the report of the Canadian Engineering Manpower Council. We suggest that, unless there is an acceptable explanation for the divergence between CEMC and the consultants, great care be taken in using any manpower forecasts.

The proposal (section 7.6) concerning a Doctor of Engineering program is interesting as an example of the market value of the title "doctor". The description of the possible program seems to be consistent with a graduate diploma rather than with a graduate degree.

We agree with the consultants (recommendation 3) that there should be consistency in the admission requirements of PhD students. But we consider that it is unnecessary to depend upon external individuals (or, even, bodies) to ensure that only very good students are admitted. All that is required is that the discipline group review annually the credentials of the students admitted to PhD studies in the preceding year. A report through ACAP to OCGS and COU could be a very effective way of maintaining high admission standards.

Finally, we note the concern about BIU's set out in recommendation 5, although we find the argument somewhat elusive. In any case, we understand that a proposal is currently (October 1973) under review by COU and CUA for the revision of the existing BIU structure. Our chief concern is to ensure that the research supervision of PhD students be recognized as making a higher demand upon the Professor/Supervisor than is made at the Master level. It is hoped that a BIU differential will continue to recognize this fact.

****

October 26, 1973

RESPONSE BY McMASTER UNIVERSITY

TO

CIVIL ENGINEERING DOCTORAL PLANNING ASSESSMENT

We have noted carefully the report of the assessors on doctoral studies on civil engineering. In general terms, we express disappointment in the report in its failure to deal adequately with its two main tasks, (a) reporting on the adequacy of the present status of doctoral work through a detailed presentation and quality evaluation, and (b) recommendations for the development of doctoral work. Our general criticism is highlighted by the introductory statement (page A5), "The question of quality or accreditation we have only regarded as relevant to the extent that it has an impact on the plan to enter a new area of study or if a large growth of Ph.D. students is anticipated". We find it impossible to reconcile the content of the report with the statements (page A5) that the assessors have "formed our own judgement about the strengths of the different Civil Engineering departments" and (page A6) where they claim that the sections on each university give "a summary of the current and proposed Ph.D. activity together with our own general impressions". The statements on each university (pages A25 to A30) are brief, bland, and non judgemental. Further, they provide little of the detailed discussion called for in the assessors' terms of reference. Nowhere do their "judgements" appear with any specificity, nor does the type of documentation which would have supported such judgements. In more specific terms, the failure to assess and compare such indicators as research grant level (NRC and all other grants-in-aid), publications and patents, facilities, graduate student supervision, Ph.D. program requirements, etc. has made it impossible for the assessors to present a truly credible report.

While some attention is paid to overall groupings within civil engineering, this is not viewed in detail nor contrasted against any detailed projection of need or demand for Ph.D. students. In transportation there is an exception made, and the proposal for expanded efforts is one which it is easy to support. At the same time, no helpful proposal is made as to estimates of how, where and when this should be developed, nor even some invocation such as a further appraisal with such a development specifically in mind. This attitude of the consultants towards the area of transportation planning is perplexing. Throughout the report the impression is given that insufficient attention is given to this important subject, but in the recommendations it is proposed that no new programs be offered by any school. If this is meant to imply that those schools now offering transportation should increase their efforts, it should be stated so explicitly. At McMaster, a significant opportunity exists for very useful work on a modest scale through close collaboration with the Department of Geography. It is suggested that the necessary ingredients of "a good student, a good professor and a good problem" (page A32) may well occur in the area of transportation planning in this

Department, and would help to correct the bias in favour of non-structural topics mentioned in recommendation 8.

While it is not possible to link the report's recommendations on student numbers with specific areas of civil engineering, we pay tribute to the efforts of the consultants to analyze at some depth the manpower situation. Their report provides a useful counterpoint to the CEMC report. The consultants, however, while noting that the latter report produces a supply over demand factor of 18 for civil engineering, still use the overall CEMC reduction figure of 20%. The estimates of demand and need provided by the consultants are helpful judgements and do provide useful criticisms of the CEMC report as to the wariness with which its numeric conclusions should be examined. The assessors, having derived at least some rationale for 20% reduction, then assert ranges for each university. We do not find these totally unacceptable even though they are linked almost solely to each university's stated plans, and appear with no evidence of any real attempt at rationalization. We must, however, press for some improvement in rationale where the report praises McMaster's strength in structural dynamics and earthquake engineering (one of the very few specific quality judgements given) yet gives no effects to it in terms of recommended five-year enrolment ranges. Adequate recognition of such strengths should be reflected in a range of at least 8 to 12 in our view rather than 6 to 10. In the area of enrolments of Ph.D. students, our sense of frustration at real definiteness, detail and direction in the report is further illustrated by noting such a vague statement (page A18) as, "As a whole we feel that the enrolment in each university does not go above the capacity of the civil engineering department."

The report speaks to the philosophy for civil engineering Ph.D. program development and does mention the systems design aspect, though not in any context of growth or applicability to many of the traditional groupings. It seems doubtful to us that any school is currently unaware of the general theses proposed in this regard - so no major thrust of progressive development for new directions or emphases is given other than support for a D.Eng. degree, already strongly recommended in the "Ring of Iron".

We wish to respond specifically to the twelve recommendations.

Recommendations 1 and 2 are relatively meaningless and not helpful.

Recommendation 3, while interesting, does not seem to us to be dealing with a major problem. Our own admissions procedures are on a University-wide basis, and involve non-engineering faculty in admission decisions. We suggest that the most important criterion is the quality of the Ph.D. graduate, and that this is adequately ensured by including external faculty on examining committees.

Recommendation 4 is, of course, an acceptable statement that then begs the real question as to what criteria should be or have been established which, in the assessors' judgement, can provide a satisfactory environment.

Recommendation 5 seems to be beyond the terms of reference for the assessors.

Recommendation 6 is based on useful and good information and we fully support it.

Recommendation 7 we find acceptable in an overall sense, but would wish to see a coordinated emphasis on developing effective means for increasing the percentage of Canadian university graduates proceeding to graduate work.

Recommendation 8 is acceptable but more quantitative proposals regarding the areas in which proportions should increase, along with detailed justification, would have been more appropriate.

Recommendation 9. Our objection has already been stated regarding our own University where an emphasis on earthquake engineering should well have resulted in a slightly larger proposed enrolment if quality assessments combined with needs are to be invoked adequately.

Recommendation 10 seems inconsistent with a recommendation in the body of the report for increased emphasis on transportation, as mentioned above. Further, it fails utterly to deal with means of promoting improved quality and performance.

Recommendation 11 is acceptable and indicative of easily discerned efforts being made at all universities.

Recommendation 12 offers a re-affirmation of a "Ring of Iron" recommendation which can be important in stressing the need for progress in this area. However, we find the case acceptable in principle but unconvincing in detail since the report does little critical evaluation of current Ph.D. programs and requirements. As a result, it may well be easier to achieve the aims for the D.Eng. degree by adaptations of the Ph.D. programs.

6 November, 1973

C-16

UNIVERSITÉ D'OTTAWA
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UNIVERSITY OF OTTAWA
550 CUMBERLAND STREET

OTTAWA, ONTARIO
Canada K1N 6N5

CABINET DU RECTEUR

OFFICE OF THE RECTOR

November 5, 1973

Dr. M.A. Preston,
Executive Vice-Chairman,
Advisory Committee on Academic Planning,
Ontario Council on Graduate Studies,
Council of Ontario Universities,
102 Bloor Street West,
TORONTO, Ontario. M5S 1M8.

Dear Dr. Preston,

This is a reply to your request for the University's comments on the consultants' report to A.C.A.P. on the discipline of Civil Engineering. In general, the University has little to add to this report.

We note with interest the statement made in the report regarding the future increased demand for graduate studies in the fields of Transportation and Water Resources Engineering. In this connection we should like to emphasize that the University of Ottawa has a strong group in the Water Resources-Pollution Control area. This is evidenced in the recent substantial grant made by the National Research Council ($500,000 over five years) to six professors of the University (two in the Civil Engineering Department) to produce, in co-operation with certain N.R.C. personnel, predictive ecological models for the Ottawa River. The decision to continue its emphasis on this area in its graduate program will considerably influence future staff appointments in our Department of Civil Engineering.

I should draw to your attention that we are experiencing an increased demand from engineers in the Federal Government here in Ottawa (particularly in the Department of the Environment) for graduate programs in the Water Resources-Polution Control field. In this connection we find the consultants' recommendation (p.A-53) for the creation of a D.Eng. degree with a modified residence and thesis requirement a sensible approach to the question of part-time professionally oriented doctoral programs. We are discussing the possibility of introducing a program of this type in Civil Engineering.

Yours sincerely,

Roger Guindon, O.M.I.,
Rector.

UNIVERSITY RESPONSE TO ACAP CIVIL ENGINEERING ASSESSMENT REPORT

Queen's University feels that, in the main, the Report is essentially acceptable in view of its workable recommendations.

However, Queen's University feels that the consultants, in their report, declined to address themselves to the question of quality in the planning function. This omission gives the unwarranted impression that all civil departments are of equal quality in all areas. The Report would have been of much more value to both ACAP and Queen's University had it contained reference to the various quality judgements which the consultants admit they formed during their visits.

Enrolment limits should not be imposed at this time in view of the highly questionable figures in the Lapp-Thomson demand survey for Civil Engineering and the fact that there is no serious over-production of Civil Ph.D. students at present or in the foreseeable future at Queen's University or in the other Ontario Universities.

In conclusion, Queen's University commends the Report, notwithstanding the above criticisms, for its air of forthrightness.

With respect to the Conclusion and Recommendations contained in Chapter 9 of the Report Queen's University wishes to make the following observations.

1. Self-evident, has no bearing on real issue.
2. As above
3. This recommendation involves a considerable measure of centralized control which Queen's University feels is detrimental to the inherent responsibility for quality within the individual university.
4. Agreed
5. Agreed
6. No comment
7. Queen's University sees no basis for this conclusion, based as it is on totally questionable manpower data surveys for the civil profession in particular.
8. Agreed
9. Queen's present plans for the number of Civil Engineering Doctoral Students are in line with this recommendation. However, since Queen's constantly modifies its plans to the changing situation any codifying of these figures for Queen's or other Universities involves a measure of centralized control which Queen's strongly resists.
10. Agreed for the immediate future except that Queen's feels the "no reduction" should be removed.
11. Agreed
12. Will be given serious study.

November 12, 1973

UNIVERSITY OF TORONTO
School of Graduate Studies

OFFICE OF THE DEAN
Toronto 181, Canada

October 29, 1973.

Dr. M. A. Preston,
Executive Vice-Chairman,
Advisory Committee on Academic Planning,
Council of Ontario Universities,
102 Bloor Street, West, 3rd Floor,
Toronto, Ontario,
M5S 1M8.

Dear Dr. Preston,

The University of Toronto finds that the Report to ACAP by the Civil Engineering Consultants is a useful, but inadequate, summary of graduate studies in that discipline in Ontario. We are disappointed that the consultants did not make evaluations, explicitly or implicitly, of individual departments, nor of the quality of the programs which they offer. All the Ph.D. programs in Civil Engineering in this Province have been developed fairly recently. Assessments of individual departments in regard to the quality of their staff, their students and their programs, with an indication of the strengths and weaknesses of these, would have been most helpful to the departments as well as to their universities, and in our view is an essential aspect of the planning process.

The consultants wisely reject the manpower forecasts made in the CEMC Report on the Supply and Demand for Engineering Doctorates in Canada, though they turn to this report to confirm their own estimates of demand (A-39). We believe, given the uncertainty of forecasting techniques, that the projected 20% reduction in demand is well within the probable range of error of such forecasts. As a result, the discrepancy between demand and supply cannot be taken to indicate gross oversupply of Ph.D.'s in Civil Engineering. Consequently, we do not accept the recommendation (No.9) that departments should be constrained by the five-year range given in Table 13. According to the policy adopted by COU in July 1973, (Memorandum on Approach to Planning Graduate Studies), some controls will be needed in situations where "the predicted needs seem to be grossly out of line with the universities' plans". The situation in Civil Engineering hardly calls for the application of departmental allocations as suggested by the consultants. There continues to be an awkward dichotomy between the terms of reference given to consultants, which ask for desirable ranges of enrolment by universities, and the policy of COU, which points to possible university by university controls only where gross oversupply exists. We believe this problem will continue until the consultants are asked to indicate desirable university enrolments only where they believe gross oversupply exists.

We do not wish to comment at length on the question of 'critical size' which has already received a great deal of consideration in previous reports and in ACAP's discussions. As a general approach, however, we cannot accept the 'master-disciple' model inherent in the view that the ingredients for a worthwhile and productive doctorate consist simply of a good student, a good professor and a good problem. Such a model seems to disregard course work, equipment needs, and work in related areas, to say the least.

We support the consultants' view that too few Canadians are doing graduate work in Civil Engineering. The figures given in Table 3 indicate a serious imbalance in the numbers of Canadians, of landed immigrants, and of those on student visas.

The following brief comments are in response to specific recommendations (numbered as on pp. A-52 and A-53 of the report).

3. Placing an external examiner on admission committees would impose yet one more constraint on an already unwieldy process. The University of Toronto already requires an external examiner for all final Ph.D. thesis examinations.

5. No doubt consultants should be able to comment on relevant items not in their terms of reference, but their discussion here is so brief and tendentious that their recommendation should not be given much weight, if any.

7. We have indicated above that we do not see indications of a gross oversupply of Civil Engineering Ph.D.'s, for their discrepancy between demand and supply is well within the error limits of such estimates.

9. As noted above, we do not accept this recommendation.

10. We believe that program reductions should be possible without need for special permission from a provincial body, should the individual university wish to make such a reduction. However, a warning should be given that in some cases a reduction might leave a program which is no longer viable.

11. The Dean of Graduate Studies at the University of Toronto has established a committee to examine part-time graduate studies in all divisions, including the possibility of part-time doctoral studies. A decanal committee to consider inter-departmental studies has also been appointed. Both committees are expected to report in May or June of 1974.

12. This recommendation requires careful study. It is not clear at the present time in what ways the degree requirements for a D. Eng. might differ from those of the Ph.D. Introduction of part-time doctoral studies, presumably with changes to the residence requirements, does not appear sufficient reason for instituting a new doctoral degree.

We believe that the consultants' report would have been more useful had it contained evaluations not only of the quality of graduate studies in Civil Engineering in this province, but also of individual departments and programs. We suggest that ACAP invite the consultants to make such evaluations before ACAP reports to COU. Moreover, we believe that this and a number of other reports would have been of much greater value if the consultants had had access to earlier reports, and we urge that this policy be instituted as soon as possible. It seems unbelievable to me that the experience of the earlier reports, in terms of what can be learned from both their strengths and weaknesses, is not available to each group of consultants.

Yours sincerely,

for A. E. Safarian,
Dean.

:erb

cc - The President
Mr. Sword
Professor Foster

Response of the University of Waterloo to the Report of the Civil Engineering Consultants to the Advisory Committee on Academic Planning

submitted to ACAP, November 7th, 1973

The reaction of the University of Waterloo to the report of the Civil Engineering consultants is a mixed one. While there is much in the report with which we are in agreement and while we can support some of the recommendations which the consultants present, there are other parts of the report with which we cannot agree and some recommendations which we cannot support. We also wish to express our overriding disappointment that the consultants did not address themselves to the question of the relative quality of the programmes in the province. The consultants state on Page A-5 of their report that they have treated their assignment as "being one of giving guidance on planning". They go on to say that the question of quality they have regarded as relevant "to the extent that it has an impact on the plan to enter a new area of study or if a large growth of Ph.D. students is anticipated relative to the current number of students". Surely the question of quality is equally important in deciding whether or not a programme can sustain its present level of activity. The consultants have not addressed themselves to this problem and to that extent in our view they have failed to meet their terms of reference.

In this response we will make some general comments on statements in the report which pertain to all of the programmes in the province. We will comment separately on the section on manpower forecasts. We will make specific comments on statements in the report that relate to the University of Waterloo and finally we will comment on the recommendations.

General Comments:

In Section 2.2, Page A-8, the consultants comment on the changing climate in Civil Engineering. They point out the vital importance that Ph.D. programmes reflect this changing emphasis and prepare students to take their role in the universities, in industry, and in government, in the changing environment which they will encounter. We wish to lend our support to the views expressed by the consultants in this section of the report.

On Page A-18, the consultants comment on the fact that too few Canadians are doing graduate work in Civil Engineering. This is a problem with which the universities have been wrestling for many years not only in the field of Civil Engineering but in all of the engineering disciplines. We have made every effort at Waterloo to encourage our engineering undergraduates who have the academic qualifications to go on to graduate work. The consultants suggest that a greater emphasis on part-time programmes might attract more Canadians. We are not entirely convinced that this is the case. We do agree with the consultants, however, that increasing the level of financial support for students would make graduate work more attractive to Canadians. This is particularly important if we want to be in a position to attract Canadian engineers who have spent some time in industry to return to university for graduate work. At the present level of support for graduate students, the remuneration is usually too low to attract such people into full-time graduate work. While a part-time programme allows the student to continue his employment and therefore is financially attractive, part-time graduate work at the doctoral level poses a great many problems that are not easily solved. We do not feel that a wholesale launching into part-time doctoral studies in the province would be a wise move. We do support the view, however, that in individual cases, the opportunity to pursue the doctorate on a part-time basis should be available if conditions make this viable. This opportunity is already available at Waterloo.

There are two general statements in this report with which we feel we must take particular exception. At the top of Page A-31, the consultants suggest that the universities have been so preoccupied with expanding their facilities and erecting buildings that they have neglected the educational content of their graduate programmes. They suggest further that the time of financial stringency which we are now entering will force the universities to address themselves to the educational aspects of their programmes. This is a serious allegation and is made without any supporting evidence whatever. The University of Waterloo rejects it categorically at least with respect to its own programmes. The development of graduate work in Civil Engineering that has taken place in this institution over the last fifteen years has led to the emergence of some programmes which have achieved international recognition. To suggest that these programmes were developed without there being sufficient concern with the educational content is, in our view, totally unacceptable.

The other comment with which we must take exception is that on Page A-33 in which the consultants imply that students have been given advice as to where they should go for graduate work which was based on consideration of the BIU income which the students would bring to the university rather than on academic considerations. Again this allegation is made without any supporting evidence being presented. The statement is in fact a reflection on the professional integrity of the faculty of our university and we reject it. We know of no case where students at Waterloo have been advised to carry on their graduate work at this university solely because of the BIU income which they would generate for this university. Indeed, we know of many cases where students have been advised to take their graduate studies at other universities both in Canada and abroad when the programme being offered at those universities better suited the needs and interests of the student concerned.

In Section 5.10 on Page A-31 the consultants address themselves to the question of the size of doctoral programmes. They refer to the concept of critical size and tend to reject this concept although they concede that there are arguments on both sides. The University of Waterloo rejects the view that a productive doctoral programme consists of a good student, a good professor and a good problem if the student and the professor are operating in isolation. For any doctoral programme to be successful, there must be the opportunity for interaction between students and faculty that provides the kind of environment for learning that is essential. In a small Civil Engineering department, this environment could be provided by interaction with other engineering departments or departments in science and mathematics. Such interactions will not come automatically, however; a good deal of effort is needed to establish them. There must be evidence of their existence before we would agree that a small programme can in fact be viable. Indeed, as pointed out by the consultants on Page A-38, the students themselves expressed some unhappiness with the range of courses offered in the small schools and some students criticized the laboratory space and library facilities available. It is more likely that a small school will be unable to provide the laboratory and library facilities needed to support a programme. More importantly, we feel that the consultants' defence of very small programmes is inconsistent with their call at the beginning of their report for doctoral work to be more responsive to the changing needs of society and the expanding breadth of the field of Civil Engineering. We feel that the students are more likely to achieve the necessary breadth and to have the opportunity to study in other branches of their field beyond their own thesis problem in a programme which is of a reasonable size.

Comments on Manpower Forecasts:

The section of the report on manpower forecasts, Chapter 7, is one with which we are in general agreement. In particular, we wish to support the consultants in their criticism of the report of the Canadian Engineering Manpower Council. We agree with the consultants that that report has grossly underestimated the demand for Ph.D.'s in Civil Engineering. Indeed, we feel that the consultants own estimate, while being much more realistic, may still be somewhat low. Our own Ph.D. graduates have had no trouble in getting jobs. Indeed in the fields of transportation and materials and in some areas of geotechnics, the demand has exceeded the supply. We are confident that this demand will continue and that to curtail doctoral enrolment in Civil Engineering at this time would be a grave error.

Specific Comments:

We wish now to make some comments on those parts of the report that make specific reference to the programme at the University of Waterloo. In Section 3.2, the consultants set out the Ph.D. programme requirements for all of the universities involved in doctoral work. Unfortunately the requirements for the University of Waterloo as listed on Page A-20 are incorrect. The university does not require the M.Sc. plus industrial experience for admission to the doctorate in Civil Engineering. There are certain groups in the Civil Engineering Department which prefer to have students who have had industrial experience but it is by no means a general requirement. The statement that course work is established by the supervisor is also misleading. The student's course work programme is worked out by the student in consultation with his supervisor and subsequently must be approved by the student's supervisory committee.

While the university has no formal course requirement for the doctorate, nearly all of our students will take some courses. The typical programme would run to four courses. Some students would take more than this while others might take fewer. In each case, the course programme must provide the student with the necessary background for his thesis research and with the necessary breadth in his field. Finally, the statement that there is no residence requirement for doctoral work in Civil Engineering at the University of Waterloo is incorrect. The university's residence requirement is set out in the University Graduate Calendar and we include it as an appendix to this report for information.

In Section 5.7 on Page A-28, the consultants comment on this university's programme. We wish to comment on some of the points raised. The statement that part-time and non-resident doctoral work is being developed is somewhat misleading. The University of Waterloo does not have any part-time doctoral programmes. It does have provision whereby individual students may have the residence requirement decreased or waived entirely if certain conditions are satisfied. We believe that non-resident doctoral work must be handled on an individual basis.

The consultants comment on the need for increased coordination between Civil Engineering, Chemical Engineering and Geotechnics in research and academic programmes in the environmental area. The university has recognized this need for some time and has taken a number of steps to improve the situation. A good deal of coordination has been developed between the Civil Engineering Department and the Department of Earth Sciences where there exist contiguous areas of interest in research. There is also cooperation between the Civil Engineering Department and the Applied Ecology Group in the Faculty of Environmental Studies.

In the general context of their report, the consultants comment on the need for universities to decrease the emphasis on structural work in Civil Engineering. We would like to point out that the structural umbrella at the University of Waterloo involves work in a wide variety of fields and is much broader than would be implied by the title. In particular, there is work included under this general umbrella in the areas of control, materials, vibration, and bioengineering.

Finally, we wish to comment on the enrolment range suggested by the consultants for our programme. It is clear from the table on Page A-47 that the suggested five-year range is reasonably consistent with the university's own long range projections. We would like to point out, however, that we have very little confidence in the accuracy of our enrolment forecasts beyond the next two years. Circumstances could change significantly and could result in the projections being substantially wrong. As long as planned enrolment levels are subject to regular review, this need not be a problem. We can therefore accept the enrolment recommended for the University of Waterloo provided that the numbers are subject to review if circumstances dictate.

Comments on Recommendations:

In the final chapter the consultants present a number of conclusions and recommendations. We have already commented on our position with respect to some of these recommendations but will summarize that position here.

Recommendation 1 we fully support.

Recommendation 2 is rather empty of any content since it simply suggests that the university should recognize the conflict between research versus course content in the Ph.D. programmes, a problem that has indeed been recognized by the University of Waterloo for quite some time. Since the consultants make no recommendation as to how this conflict is to be resolved, however, there is little we can say.

We are not in agreement with Recommendation 3. We believe that each university must set its own standards for admission of students and then must be judged on the quality of the graduates that it produces. If the consultants have any question about the quality of any programme based upon their assessment of the quality of the students, then they should have recommended that those programmes be submitted for appraisal.

We have already expressed our views on Recommendation 4 and have no further comment.

Recommendation 5 goes beyond the terms of reference of the consultants. Their proposal is not realistic and indeed is extremely naive.

Recommendation 6 refers to the counselling which students get. We assume that this means career counselling and, while we echo the desire of the consultants that this should be improved, we would point out that the best way to achieve good career counselling is to have it carried out by faculty who are themselves familiar with the needs of industry.

In Recommendation 7, the consultants use the word need for Civil Engineering Ph.D.'s. We submit that they have not assessed the need but rather the demand, and that these are different things. While they may be correct in assuming that the demand for Ph.D.'s will drop by some 20% compared with present levels, we feel that this conclusion should be accepted with a good deal of caution.

With respect to Recommendation 8, we have already pointed out that at Waterloo structural engineering covers a much broader range of activity than is implied by the title.

Recommendation 9 we have already commented on.

We have no comment on Recommendation 10.

We have commented at length in the body of our report on Recommendation 11. In summary, we do not agree with the proposed development of part-time doctoral programmes but believe that individual students should be given the opportunity to pursue their doctoral work on a part-time basis under certain carefully developed conditions.

Recommendation 12 is one with which we are not in agreement. We do not believe that it is necessary to develop a Doctor of Engineering degree in order to achieve the necessary flexibility that the consultants feel is desirable. At Waterloo, we have achieved this flexibility within our own Ph.D. programme and we have no intention of introducing another Doctoral degree in the field of engineering.

Appendix: Residence Requirements
University of Waterloo

Ph.D.	Normal)	six terms from Master's degree, nine terms from Honours Bachelor's degree.
	Minimum)	four terms from Master's degree, six terms from Honours Bachelor's degree.

In exceptional cases some, or all, of the residence requirements may be waived.

Response of the University of Western Ontario to the Report of the Consultants on Doctoral Programs in Civil Engineering of the Advisory Committee on Academic Planning.

October 25, 1973

This report was prepared by a Committee of Senate charged with generating a response to the ACAP Consultants' report on doctoral studies in Civil Engineering.

The Committee wishes to commend the authors for a thoughtful and perceptive analysis of the discipline which recognises more clearly than did its predecessor, the "Ring of Iron", the various activities embodied in the Civil Engineering Group at this University. There are certain matters which we feel should be drawn to the attention of the Advisory Committee on Academic Planning which were omitted from the report or which the Committee felt required particular emphasis.

1) While interdisciplinary activities at some Universities were noted in the comments on those Universities, the corresponding collaborations at this University between Geology and Geophysics in the Geotechnical Field and Applied Mathematics in the Structural Area were not noted in this report. Some of the details of these collaborations were dealt with in an earlier report on the Solid Earth Sciences which seems not to have come forward for final assessment.

In this connection, it should also be noted that because the Faculty of Engineering Science at Western is not subdivided into a Departmental structure, cooperative activities within the Faculty are greatly facilitated.

2) The consultants identified a need for a Doctor of Engineering degree. This matter is under study at this time and our position remains to be defined. However, we do recognise the importance and the desirability of increasing interaction between industry and our doctoral program.

3) A number of comments bearing directly upon the existing doctoral program may be recorded:

(a) The enrolment proposed by the consultants for this University is acceptable to the institution;

(b) The Committee believed that the University should be the authority charged with determining who shall be in its student body. They, therefore, do not accept as desirable the proposal that an external 'referee' be established to review the admission qualifications of each doctoral candidate;

(c) The Committee found merit in the proposal to make student support available at such a level as to make doctoral study a reasonable alternative to junior professional practice of engineering. It is felt in this way that good Canadian students will be attracted to doctoral studies. (See final paragraph on A-38 of Consultants' Report).

4) As a general comment the category "Structural Engineering" as used in this report is very broad. The reductions proposed for the structural group were considered desirable and were agreed to by the Committee. However, it was recognised at the same time that particula specialties within structural rubric should not be cut back (including some proceeding at Western, e.g paragraph iii A-50) and that care should be exercised in developing recommendations based on the consultants' classification.

A Response of the University of Western Ontario to the Advisory Committee on Academic Planning with respect to the Engineering Specialty Assessments (1973).

November 29, 1973

Historical Aspects

Approximately 20 years ago (1954) on the recommendation of the Faculty of Arts and Science the Senate of the University of Western Ontario established a Department of Engineering Science. This Department undertook to gather the faculty necessary to establish an independent Faculty of Engineering Science and Faculty status was granted to this group in 1960. The beginning of formal graduate study was the offering of an M.E.Sc. program which received the approval of the Faculty of Graduate Studies and Senate in 1961. The first candidates (4) were admitted in September 1962 and by 1964-65 the number of M.E.Sc. candidates had risen to 18. In October 1964 the Faculty of Graduate Studies approved the establishment of a Ph.D. program in Engineering Science and the Senate supported this action on January 29, 1965. From the outset an effort was made to emphasise the interdisciplinary nature of the program and graduate training was offered in a limited number of areas which at that time included chemical and biochemical engineering, soil mechanics, structural engineering and thermodynamics. Since its inception the Ph.D. program has produced a number of graduates

1969 - 1
1970 - 1
1971 - 6
1972 - 6
1973 - 6

In 1973-74 there were enrolled in the Ph.D. program 29 full-time students and 15 part-time students. All of these students have received or are enrolled in programs leading to a Ph.D. in Engineering Science and none of them has received a degree designated as serving one of the traditional specialties of engineering (e.g. chemical, mechanical, etc.).

The "Ring of Iron" published in 1970, among other things, recommended that the Faculty of Engineering Science drop the "Science" from its name (Ring of Iron, p. 77). The Faculty, after considering this matter, elected to retain this name as it did its interdisciplinary programs. The "Ring of Iron" did recognise the interdisciplinary nature of the programs by recommending that Western "concentrate" on environmental engineering which was acknowledged at that time to be a foretaste of the future. At that assessment it was also noted that "Western has gained distinction with its work in industrial aerodynamics, electrostatics and bioengineering". (Ring of Iron, p. 76).

Present Assessment

As a consequence of dissatisfaction with the stringency of Ph.D. recommendations in the "Ring of Iron" as adopted by the Council of Ontario Universities, the Council of Deans of Engineering has sought a reassessment of the Ph.D. programs in Ontario Engineering Schools. This task was undertaken under the aegis of the Advisory Committee on Academic Planning and something which has been erroneously termed a "mini-appraisal" has been performed.

The conditions under which this appraisal was undertaken are of particular interest because the form which this assessment has taken fails to take cognizance of work of an interdisciplinary nature which may be deemed to be outside the traditional specialties of civil, electrical, mechanical, chemical and metallurgical and materials sicence engineering. Examination of the five reports which have been received reveals rather remarkable differences between reports in spite of the fact that the consultants seem to have been given substantially equivalent instructions (with the possible exceptions of mechanical and chemical groups who do not specifically report their terms of reference). Remarkable perhaps are the prevalent comments about "critical size" when the printed terms of reference contain no mention of critical size.

As the present assessment has been conducted, it seeks to determine whether the engineering schools of the province contain five individually certifiable traditional specialties of engineering. If this was the objective of the assessment it was not so stated in advance. Not surprisingly, the large schools with substantial groups in each of the specialties survive assessments of this sort. The smaller schools regardless of the quality of their operations when judged in this particular frame of reference are found wanting in one or more of the traditional specialties. That is not to say that the discipline is not represented in the school since it must be to meet undergraduate instructional needs but the group practising the specialty is small and does not meet some arbitrarily defined critical size.

What can a school that is faced with this difficulty do? Aside from the obvious and in general unacceptable possibility of retiring from competition the researcher in the small "sub-critical" groups seeks to meet the need for interaction with other professionals and to develop his own intellectual pursuits by developing liasons with other individuals in related fields. The consequence is that individuals with different backgrounds, information and skills address themselves to problems which they have in common. At its best this kind of development can be the most exciting research conceivable. At its worst the products of the activity may be minimal or zero. However, we would contend that operations of this sort which stem from small interdisciplinary groups are potentially of great importance and furthermore, that the present assessments carried out along stereotyped lines may not detect these activities and are likely not suited to the evaluation of them.

It will be evident that interactions with individuals in other disciplinary specialties, however integral to the research in hand, will not permit the specialist group sparsely represented on staff to meet the criterion of critical size when the assessment is carried out in the framework of traditional disciplines.

The situations which prevail at Western in which these difficulties of assessment are most easily identifiable lie with the Electrical and Materials Science groups although the prevailing interdisciplinary attitude of faculty members in other groups leads to a reduction in the vertical integrity of the traditional specialties and to an enhancement of horizontal interactions between specialties. Encouragement of this horizontal interaction has been a conscious policy within the Faculty of Engineering Science and is a major determining factor in the decision of the Faculty to offer an Engineering Science program rather than programs in the traditional specialties.

The Engineering Science Concept

The absence of departmental structure and all that it contributes to specialty tribalism, the limited dimensions of the Faculty (approximately 43 F.T.E.), and the existence of congenial relations has led to development of extensive interaction and collaboration between groups within the Faculty. For similar reasons it has also been possible to develop interfaculty research activities in the biomedical area, (collaborative activities in both biomedical engineering and applied physiology), in radioscience (as participating members in the Centre for Radioscience) and in computer science (where the systems engineering group has developed a collaboration). The abiding interest of the Faculty in environmental matters has promoted interaction with other parts of the University which may be expected to bear fruit in the future. It should be noted that in all five of the assessment reports the comments on the quality of the work in hand were favorable.

In effect, circumstances have dictated that a particular course of development be followed. It would be our contention that this course has led to much that is valuable and worthy of development. While the route we pursue may be inappropriate to other Engineering Schools we would request that we be judged in this framework and not in the traditional format which cuts across rather than displays our most effective activities.

These remarks may be concluded by a statement that as recently as November 14, 1973 and with the full knowledge of the various consultants reports, the Faculty of Engineering Science reaffirmed its intent to continue to offer undergraduate, masters and doctoral training in Engineering Science and not in any of the specific sub-disciplines.

UNIVERSITY OF WINDSOR

RESPONSE TO THE ACAP CONSULTANTS

"Report on Doctoral Programs in Civil Engineering in Ontario Universities"

We recommend that the Report from the ACAP Consultants on the Civil Engineering Doctoral Planning assessment be accepted favourably. The following points are stressed:

1. It is very reassuring to find that the Consultants conclude that a successful Ph.D. programme is independent of the size of the department.

2. The recommendation on part-time studies for the Ph.D. degree student is worth considering. The residency requirement might be relaxed and the student allowed, whenever possible, to carry out his research in a laboratory outside the University under the supervision of a Professor.

3. Design orientated research topics of some benefit to the Country should be encouraged.

4. Collaboration between neighbouring universities and sharing of facilities should be actively pursued.

5. If necessary, more consistent requirements for acceptance to Graduate Schools in the Province of Ontario would be adopted and supervised possibly by O.C.G.S. If there is admissions inconsistency in Engineering departments, a review of admissions annually by CODE could be very salutary.

6. The University would like to support the ACAP Consultants in rejecting the CEMC forecasts for Civil Engineering Ph.D graduates.

7. As recommended by the Consultants Report, the University of Windsor will make a serious attempt to strengthen further its present programme in Water Resources. In this regard, increases in laboratory space would be considered.

8. In order to attract more Canadian students to our Graduate Schools, the financial aid to such students should be substantially increased. Item 2 above will be of aid in this respect. However, any imposed upper limits of financial support must be strictly adhered to by all the universities.

APPENDIX D

PROCEDURE OF PLANNING STUDY AND TERMS OF REFERENCE

Procedure for Civil Engineering Doctoral Planning Assessment

conducted by ACAP in cooperation with CODE

1972-73

A. Tasks Requested from Discipline Group (with help available from ACAP at all stages)

A.1. Meet with representatives of ACAP and CODE and discuss the specialty fields assigned to this assessment. An initial meeting of the five engineering discipline groups may prove desirable. The field allocations may be altered by ACAP as a result of these discussions and CODE comment.

A.2. Suggest a panel of suitable consultants from which ACAP may choose. ACAP will refer the list to CODE for comment before acting.

A.3. Examine and comment on pro formae to be used for the gathering of information on current, past and future programmes as described in paragraph B.1.

A.4. Examine and comment to ACAP on the adequacy of the data collected on current and past strength. CODE will also be asked to comment on the data reliability.

A.5. Both in consultation with ACAP/CODE representatives and separately, consider the situation revealed by the tabulation of proposed future programmes and consider whether future plans should be modified or developed in more detail. As a result of this step, individual universities may wish to revise the material described in B.1.d below.

A.6. Possibly develop a tentative plan for development of established or new doctoral work in Ontario paying attention to adequate coverage of fields and specialties. Any such plans will be reported to ACAP which will transmit them to the consultants and to CODE.

A.7. For this assessment, the discipline group shall consist of a member of each of the Departments of Civil Engineering, that member being the chairman unless the chairman delegates this responsibility to a colleague on a permanent basis.

B. Information from Universities

B.1. Each university is asked to supply to ACAP, in the form indicated by ACAP after comment by CODE and by the discipline group (paragraph A.3.).

information as follows:

a) for each specialty field determined in A.1.

    (i) current list of faculty members showing fraction of research and graduate instruction time devoted to the field (for part-time professors show the time spent on university duties);

    (ii) numbers of full-time and part-time faculty members for each of the past five years;

    (iii) for the current year and preceding five years, number of (1) master's and (2) PhD candidates and (3) post-doctoral fellows doing research in the field full and part-time shown separately.

Under these three headings one individual may appear under more than one category.

b) for each "department" which offers doctoral work in the fields of this assessment

    (i) Curricula Vitarum of each faculty member (Assistant Professors and higher) showing inter alia complete publication lists, research funding in the past five years, and graduate students and post-doctoral fellows supervised during his career, and specialization.

    (ii) resources of space - a statement indicating the department's view of the adequacy of its space, and, in connection with the future plans in (d) below, discussing future space provision;

    (iii) number of Bachelors' graduates in civil engineering and number of qualifying or make-up students each year for the last five years;

    (iv) other general items relevant to research and graduate study,
        a) major laboratories and equipment, over $5,000
        b) computing facilities;

    (v) support from related departments including shared teaching and research;

    (vi) description of any interuniversity arrangements for graduate work.

c) table of characteristics of graduate students in the department in previous five years, separately for Master's and PhD breaking down numbers by:

    (i) full-time and part-time

    (ii) immigration status (3 years) and country of first degree;

    (iii) sources of financial support;

    (iv) time to reach degree;

(v) drop-out number;

(vi) degrees granted;

(vii) post graduate employment of PhDs
  a) immediate and
  b) after two years.

d) proposed plans for the future of doctoral work, in as much detail as the department can provide, including the proposed scheme for support of these plans, and accompanied by supporting arguments, including consideration of the sources of doctoral students and an analysis of demand for graudates from the programmes as indicated by previous placement experience. The various headings in a) and b) above should be dealt with quantitatively where possible; as a minimum, planned numbers of faculty and doctoral students should be given. If part-time doctoral work is contemplated, please discuss in detail.

B.2. The material so supplied will be collated by ACAP and transmitted to the discipline group for action indicated in paragraphs A.4., A.5 and A.6.

B.3. Apart from the material described in B.1.d. and to some extent generated at the department level, each interested university will be requested to make an individual statement on its plans for the development of doctoral work in these fields of engineering, in particular the items of future commitment implied by item B.1.d.

C. Terms of Reference of Consultants

C.1. Consider the two special documents related to the coordination of the assessments in Engineering, viz. Engineering PhD Planning and Assessment Procedures, Statement on Ph.D. Studies in Engineering Studies in Ontario, and the material prepared by the discipline group and the universities and obtain other data they may require to carry out the tasks detailed below. They shall be provided with copies of "Ring of Iron", the COU statement thereon, and the CODE, OCGS and APEO responses. They may obtain data and views from any relevant source, such as, for example, employers of holders of graduate degrees, professional and learned societies, federal agencies. The campus of each interested university shall be visited by at least two consultants. Consultants shall arrange their schedule of visits to the universities in consultation with ACAP to ensure uniformity. Reports of appraisal consultants are privileged documents and are not to be made available to ACAP consultants. Consultants shall meet with the discipline group near the beginning of the work, during the work as they consider necessary, and immediately before preparing their final report.

C.2. Report on the adequacy of the present state of doctoral work in "civil engineering" in the province in general and in each university where applicable, discussing the following:

a. coverage of fields and specialties, and extent of activity in each

b. faculty quality and quantity

c. nature of programmes offered

d. enrolment size and distribution amongst universities and divisions

e. quality of student body; admission requirements

f. relationship to related disciplines and to the profession

g. physical facilities

h. other matters considered by the consultants to be significant.

C.3. Make recommendations for the development of doctoral work in fields of this assessment in Ontario between 1973 and 1978, taking into consideration such plans as may be developed by the Discipline Group, and, without limiting the generality of the foregoing, dealing with the following points:

a. Desirable doctoral programmes to be offered in the province, considering both possible limitations or reductions of existing programmes and creation of new programmes and new kinds of programmes including the appropriateness of part-time programmes. In particular, consider if there should or should not be more activity in fields now producing few graduates in Ontario and also the desirability of developing further application-oriented and interdisciplinary work and industrial involvement.

b. Desirable provincial enrolments, year by year, in the doctoral study in civil engineering and in the major subject divisions where appropriate. One should consider the need for highly trained manpower and also the general cultural and societal factors which may lead students to pursue doctoral work in engineering. In considering manpower needs, one should take account of the "market" available to graduates (at least all of Canada) and of other sources of supply for that market. Results of forecasts of high-level manpower employment should be treated with due caution and only in a clearly balanced relationship with cultural and societal needs.

c. Distribution amongst the universities of responsibility for programmes and for specialties where appropriate, including consideration of the need for any increase or decrease in the number of departments offering doctoral work and including consideration of areas of collaboration and sharing of facilities at regional level and across the province. Consider techniques for involvement in doctoral supervision of professors in departments which do not take doctoral students in their fields, and the extent to which such activity is desirable.

d. Distribution of enrolment amongst the universities, showing desirable ranges of enrolment.

In all cases, it is important that the rationale for the recommendations be clear; this is especially important for items c. and d.

C.4. It is permissible for consultants to recommend appraisals of individual programmes. This would arise if consultants were to suspect that a programme would be found to be wholly or in part below minimum acceptable standards; and appraisal by the Appraisals Committee is the means of settling the question. It is recommended that this action would be infrequent. In carrying out planning assessments in some disciplines, consultants find there to be an excess or deficiency of programmes in a given area of study, where all of the existing programmes could pass an appraisal, they may, subject to their own judgments of relative quality and of other factors (a task outside the terms of reference of the Appraisals Committee), recommend where enrolment should be changed in accordance with the possibilities indicated in section C3 (c).

D. Appointment of Consultants

The consultants shall include one person of wide academic experience in Canada but in a different discipline. The other two consultants shall be engineers of international standing, with suitable administrative and/or teaching experience, and with expertise in some of the fields assigned to the civil engineering assessment.

E. Report of Consultants

The consultants submit a joint report to ACAP (tentative date of September, 1973). Minority reports are, of course, possible. The reasoning leading to their recommendations should be given fully, in view of the subsequent treatment of the report. The report is submitted for comment to CODE, to the discipline group and to each interested university. There may be informal or interim exchanges of views amongst the discipline group, the universities, CODE and ACAP. Any university which wishes to make a formal statement to COU on the consultants' report shall submit it to ACAP. Any such report shall be transmitted to CODE and to the discipline group. The discipline group shall submit its formal comments and/or recommendations to ACAP and CODE. CODE submits to ACAP its recommendations to COU. ACAP considers the CODE, discipline group and university statements along with the consultants' report and transmits them to COU with its recommendations of the position COU should adopt. Copies of the material transmitted to COU will be supplied to CODE, to OCGS, to the members of the discipline group and to the interested universities. CODE, OCGS and the universities are thus enabled to prepare for direct comment to a COU meeting. The consultants' report may be published together with the comments of CODE, the discipline group and those of any university so requesting, and with the position adopted by COU.

Amended November 29, 1972.

Engineering PhD Planning and Assessment Procedures

Coordinating Task Force, September 25, 1972

1. The doctoral assessments in engineering are being conducted as a group. To that end there has been established a Coordinating Task Force to coordinate the conduct of the assessments in accordance with the procedures outlined in this document which is referred to in section C1 of the Terms of Reference for the Consultants.

2. All "departments" of each Engineering Faculty shall prepare a statement presenting their current and proposed PhD activities including:

   (a) areas of research and study
   (b) educational goals and style
   (c) enrolment ranges projected to five years, and other items as defined in section B of the approved "Procedure", including the basic ACAP quantitative data sheets as modified for the engineering assessments.

   The quantitative data sheets, to be submitted to ACAP by November 1, 1972, and the "five-year plans", due by the end of January, 1973, will then be distributed by ACAP to the discipline groups for consideration and planning action by the individual institutions and by the discipline groups. Copies will be made available to the members of CODE.

   Departments are encouraged to discuss their preliminary plans with the appropriate discipline group prior to formal submission in January and the discipline groups should be active in their planning function throughout this period.

3. Each Discipline Group will be charged to prepare from the statements a report on PhD activities and plans in their discipline area, noting both apparent conflicts and gaps in both areas of specialization and enrolments. Reports will be distributed as above, by the end of February, 1973.

4. Each University may modify the above statements in the light of the above and in consultation with the Discipline Groups and other Universities as appropriate. Subsequently the Discipline Groups will finalize their reports, which are due to ACAP by April 15, 1973.

5. These statements and reports, along with the regular ACAP assessment data (to be prepared during the above process, perhaps with CODE "data bank" collaboration) shall form the data base for the assessment teams. Failure to meet deadlines will not be allowed to delay proceedings.

5. The Coordinating Task Force will review the detailed terms of reference to be given to the consultant teams, particularly in the educational professional areas. This is scheduled for completion by September 30, 1972.

6. Upon completion of (4) above, the Coordinating Task Force shall recommend to CODE and ACAP whether areas in engineering not clearly included within the five major discipline areas shall be included within the total of engineering activity without further review, or included within one or more of the major discipline studies, or be subject to a small special assessment process.

7. CODE, with assistance from COU and utilizing outside expertise as needed, shall implement a special study of the engineering manpower situation at the PhD level. This study should be available for consideration by ACAP, the Discipline Groups and the consultants prior to the drafting of final reports and responses. Reports on the progress of this study shall be reviewed by the Coordinating Task Force; the first report shall be due by the end of 1972.

8. The formal assessment and consultative process shall commence on completion of (4) and the consultants shall be provided with a general statement, in addition to the data base material, terms of reference, and other relevant documents. This statement which has been prepared by the Coordinating Task Force and is referred to in section C1 of the Terms of Reference for the consultants is intended to draw attention to some features of the PhD in engineering which the Task Force considers distinctive enough to merit particular consideration by the consultants. Educational, professional and research concerns will be emphasized. Briefings and discussions with ACAP and the appropriate Discipline Group will complete the first stage of this process. These discussions are expected to occur about one month prior to the first visits and the visits themselves will be concentrated in the month of May and June.

9. The next stage consists of consideration of the available material by the consultants, University visits, meetings with the Discipline Group, and the preparation of a draft report by September 1, 1973.

10. The draft reports will be made available to the Engineering Deans and to the Discipline Groups to provide for initial feedback to the consultants. There will be oral response from the Discipline Groups to the consultants. Following this the consultants will draft their final reports which will be followed by official responses from the above groups and finally by consideration by COU. (The above is intended to make clear that while feedback to the consultants from the Discipline Groups is desired and expected, the draft reports are not to be distributed for open discussions within departments.)

APPENDIX E

Discipline Group Membership

DISCIPLINE GROUP MEMBERSHIP

CARLETON	D.L.J. Kennedy, until July 1, 1973 D.A. Kasianchuk W.H. Bowes, Acting Chairman, 1974-75
GUELPH	W. Stammers
McMASTER	A.A. Smith, until July 1, 1974 A.C. Heidebrecht
OTTAWA	*J.D. Scott, until July 1, 1973 D.R. Townsend
QUEEN'S	**A. Brebner
TORONTO	T.C. Kenney, until July 1, 1974 ***G.W. Heinke
WATERLOO	T.H. Topper
WESTERN ONTARIO	M.P. Poucher, until July 1, 1972 A.G. Davenport
WINDSOR	J.K. Bewtra, Acting Chairman, 1972-73 J.B. Kennedy

* Chairman until July 1, 1973
** Chairman until July 1, 1975
*** Chairman at present

October 1975

APPENDIX F

ROLES OF ACAP AND OF DISCIPLINE GROUPS

Ontario Council on Graduate Studies

By-Law No. 3

A By-Law to establish a Committee on the Academic Planning of Graduate Studies.

1. The Ontario Council on Graduate Studies, recognizing the importance of providing for the continued and orderly development of graduate studies in the Ontario universities, establishes a Standing Committee to be known as the Advisory Committee on Academic Planning (abbreviation - ACAP).

Interpretation

2. In this By-Law,

   (a) "Committee" without further specification, means the Advisory Committee on Academic Planning;

   (b) "Council" or OCGS means the Ontario Council on Graduate Studies;

   (c) "Committee of Presidents" or CPUO means the Committee of Presidents of Universities of Ontario;

   (d) "university" means a provincially assisted university in Ontario;

   (e) "discipline" means any branch or combination of branches of learning so designated;

   (f) "discipline group" means a body designated as such by the Committee of Presidents of the Universities of Ontario, and normally consisting, for any one discipline, of one representative from each of the interested universities;

   (g) "planning assessment" means a formal review of current and projected graduate programmes within a discipline or a group of disciplines;

   (h) "programme" signifies all aspects of a particular graduate undertaking;

   (i) "rationalization" means the arranging of graduate programmes in order to avoid undesirable duplication, eliminate waste, and enhance and sustain quality.

Membership

3. (a) The Committee shall consist of at least seven members of the professoriate in Ontario universities, some of whom shall be members of the Council.

   (b) The members of the Committee shall serve for such periods of time as the Council may determine, and they shall be selected in such manner as may provide for reasonable balance both of academic disciplines and of universities.

   (c) The members of the Committee shall be appointed as individuals.

Chairman

4. The Chairman of the Committee shall be named by the Council, and he shall have one vote.

Quorum

5. A majority of all members of the Committee shall constitute a quorum.

Functions

6. The functions of the committee shall be

   (a) To advise OCGS on steps to be taken to implement effective provincial planning of graduate development;

   (b) To promote the rationalization of graduate studies within the universities, in cooperation with the discipline groups;

   (c) To recommend, through OCGS, to CPUO the carrying out of planning assessments of disciplines or groups of disciplines and to recommend suitable arrangements and procedures for each assessment;

   (d) To supervise the conduct of each planning assessment approved by CPUO;

   (e) To respond to requests by CPUO to have a discipline assessment conducted by proposing suitable arrangements;

   (f) To submit to CPUO the reports of the assessments together with any recommendations which the committee wishes to make. A copy of the report shall be sent to Council.

Jurisdiction

7. In order that the Committee may discharge the functions described in Section 6 above, it shall be authorized

   (a) to request a university to provide such information pertaining to graduate studies as may enable the Committee to discharge its functions;

   (b) to request a discipline group to provide such information as may enable the Committee to discharge its functions;

   (c) to receive reports from the universities and from the discipline groups, and to comment and communicate with the universities and the discipline groups concerning such reports;

   (d) to convene a meeting of any discipline group for the purpose of discussing the development to date, and proposals for the future development of graduate studies in the discipline concerned;

   (e) to send one or more representatives to a meeting of a discipline group at the invitation of the discipline group;

   (f) to make such suggestions to a discipline group as may be deemed appropriate to the functions of the Committee;

   (g) to supervise the conduct of planning assessments, and to report thereon to the Committee of Presidents of Universities of Ontario;

   (h) generally to report and to make recommendations to the Council;

   (i) to seek and receive advice from appropriate experts;

   (j) to employ consultants in connection with planning assessments;

Procedures

8. The procedure to be followed by the Committee shall be as approved by the Committee of Presidents of the Universities of Ontario.

9. The Committee's function is solely advisory.

Effective Date

10. This By-Law shall take effect January, 1971.

ACAP DISCIPLINE GROUPS AND THEIR ROLES

1. Establishment of a Group

a. When it is considered desirable to activate planning of graduate work in some discipline(s) or interdisciplinary area, COU, on the advice of OCGS, will authorize the establishment of an ACAP discipline group, if it was not already approved and included in the May, 1968 list. If it is already authorized, ACAP may decide to set it up as described in paragraph b.

b. The Executive Vice-Chairman of ACAP will then invite the executive head of each university (including Waterloo Lutheran University) either to nominate a member of the discipline group or to indicate that his university has no plans for graduate study in this discipline in the next five years or so. If a university can state no plans for future graduate work in the subject, but feels that a watching brief is desirable, it may appoint an observer to the group.

c. Changes of a university's representative are to be notified by the executive head.

d. The group shall select its own chairman.

2. Meetings

a. A discipline group may meet at the call of its chairman or in accord with its own arrangements.

b. A discipline group may be called to meet by the Executive Vice-Chairman acting for ACAP.

3. Responsibilities

a. The group is to keep under review the plans for graduate work in its discipline in Ontario, including new developments and trends in the discipline, and to make reports to ACAP on a regular basis.

b. The group may make recommendations to ACAP in connection with graduate work in its discipline when it considers it appropriate.

c. ACAP will assist the group in obtaining information and data, as mutually agreed.

d. When COU has instructed ACAP to conduct a planning assessment, the discipline group will assist and advise ACAP in determining procedures and terms of reference, will report as requested and will generally facilitate the assessment.

Approved by OCGS March 22, 1973
and by COU April 6, 1973.

APPENDIX G

CURRICULA VITARUM OF THE CONSULTANTS

LIONEL BOULET

Born Quebec, Quebec, July 29, 1919

B.A., Laval, 1938
B.Sc., Laval, 1944
M.S., Illinois, 1947
D.Sc., Sir George Williams, 1968; Ottawa, 1971; Laval, 1972

R.C.A. Victor Ltd., Junior Engineer, 1944-45
University of Illinois, Research Associate, 1945-47
Laval University, Assistant Professor, 1948-50
    Associate Professor, 1950-53
    Professor, 1953-64
    Head of Department, 1954-64
Hydro-Quebec, Technical Advisor, 1964-67
    Director, Institute of Research, 1967-

Member of the Radio Sciences Committee of the U.R.S.I., Canadian Research Council, 1963
President of Association Canadienne-Française pour l'Avancement des Sciences, 1969
Member of the Canadian Association of Physicists, 1970
Member of the Board of Directors of the Institut National de la Recherche scientifique for a two-year term, 1970
Member of the Commission des Etudes techniques du Conseil Supérieur de l'Education, 1970
Member of the Board of Directors of the CEGEP Bois-de-Boulogne, 1970
President of the External Advisory Committee of the Faculty of Sciences, Laval University, 1971
Member of the Comité Franco-Québécois de l'Energie, 1971
President of the Conseil de la Politique scientifique du Québec for a three-year term
Member of the Board of Management of the Office of Industrial Research - McGill University, 1972

Applied electromagnetizer; antennas and wanguides; corona losses and radio interference on extra high voltage transmission lines

Address: Institute of Research,
Hydro-Quebec,
1800 montée Sainte-Julie,
Varennes, Quebec.

WILLIAM WESLEY ECKENFELDER, JR.

Born New York City, New York, November 15, 1926

B.C.E., Manhattan College, 1946
M.S., Pennsylvania State, 1948
M.C.E., New York, 1956

Atlantic Refining Company, Sanitary Engineer, 1948-49
New York University, Research Associate, 1949-50
Weston, Eckenfelder and Associates, Vice-President, 1952-56
Manhattan College, Assistant Professor, 1955-58;
  Associate Professor, 1958-65
University of Texas, Professor, 1965-70
Vanderbilt University, Distinguished Professor of Environmental and Water Resources Engineering, 1970-
President, Hydroscience Incorporated

Allen Memorial Award, New York State Sewage and Industrial Wastes Association, 1959

Member, American Society of Civil Engineers
Member, American Chemical Society
Member, American Institute of Chemical Engineers
Member, Water Pollution Control Federation
Member, American Society for Engineering Education

Biological treatment of sewage and industrial wastes; mass transfer and aeration in waste treatment; process design of industrial waste treatment plants; water quality management

Address: Department of Environmental and Water Resources Engineering,
Vanderbilt University,
Nashville, Tennessee 37203

BRIAN V. MARTIN

B.Sc., London.

London Transport Board, Transport Engineer, 1961-62
Massachusetts Institute of Technology, Research Engineer for Urban Transport, 1962-64
Harvard University, Assistant Director of Transport Research Programme, Department of Economics, 1964-65
Greater London Council, Chief Engineer (Transportation), 1959-69
Alan M. Voorhees and Associates Ltd., Managing Director, 1969-

Member, Institute of Traffic Engineers
Member, Institute of Highway Engineers
Member, Highway Research Board, Origin and Destination Committee, Parking and Terminals Committee
Member, City and Guilds Institute

Numerous transportation studies and consultancies. Author of textbook on transport system analysis.

Address: Alan M. Voorhees and Associates, Ltd.
112 Strand
London WC2R OAA, England.

GEORGE GEOFFREY MEYERHOF

Born Kiel, Germany, May 29, 1916

B. Sc., London, 1938
M.Sc., London, 1944
Ph.D., London, 1950
D.Sc., London, 1954
Dr.Ing., Aachen, Germany, 1973

Consulting Engineer, England, 1938-43
R.H. Stanger, Senior Engineer, 1943-46
British Government Building Research Station, Senior Scientific Officer 1946-50
  Principal Scientific Officer, 1950-53
Foundation Company of Canada, Supervising Engineer, 1953-55
Nova Scotia Technical College, Professor and Head, 1955-
  Dean, 1964-
  Director of School of Graduate Studies, 1962-64

Centennial Medal of Canada
Fellow of the Royal Society of Canada
Duggan Medal, Engineering Institute of Canada, 1958-63
Medal, British Institute of Structural Engineers, 1953

Member, American Concrete Institute
Fellow, New York Academy of Science
Member, British Institution of Civil Engineers
Member, British Institution of Structural Engineers
President, Canadian Geotechnical Society
Member, Engineering Institute of Canada

Foundation and structural engineering

Address: School of Engineering
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Halifax, Nova Scotia

APPENDIX H

RESPONSE OF THE COMMITTEE OF ONTARIO DEANS OF ENGINEERING

COMMITTEE OF ONTARIO DEANS OF ENGINEERING

RESPONSE TO ENGINEERING PhD ASSESSMENTS

Preamble

Individual reports of PhD Assessments have already been received by discipline groups and by individual universities. Both bodies will undoubtedly make detailed commentary on the specific reports which are of direct concern or interest. In view of this, CODE has decided to forego comment on such specifics, and has determined to refer only to those matters of a more general nature which affect the universities collectively. In choosing to frame its response in unitary fashion, CODE wishes, at the outset, to emphasize that it views engineering education and practice as a total activity instead of a discrete set of unrelated disciplines such as chemical, civil, electrical, materials, mechanical and metallurgy, etc. This theme of relationships between disciplines within a faculty, and indeed between faculties, will recur later in the report in subsequent discussions.

Of the ten topics on which CODE sets out its 'responses', three are considered to be of primary importance - manpower, quality, and critical size. Consequently, they have been covered in somewhat greater detail than have other topics of interest, in order to provide identification and emphasis, rather than a fully developed 'position'.

The primary concern in this response is unquestionably that of quality over quantity. In assuming this position CODE realizes that the indicators of quality are undoubtedly staff, students, programmes and facilities. It is difficult to assess the precise hierarchy of these four basic parameters. Suffice it to say that, while the first two are paramount in terms of establishing potential for excellence, the last two are important in realizing this excellence.

CODE offers its resources in such further and subsequent amplification as may be useful to the purposes of the Council of Ontario Universities.

Manpower

CODE is in agreement with the general observations of the consultants with respect to the PhD manpower situation. It appears clear that the supply of PhD candidates will be limited by the availability of high-quality entrants. The relatively small numbers of Canadian graduates entering PhD programmes is a cause for concern. If Canada is to advance industrially it would be expected that there would be an increasing demand for high-technology support. An under-supply of PhD graduates in engineering would not be in the best interest of society. There is clearly no evidence of any over-supply because of the way engineering graduates at all levels are seen to diffuse widely through industry, commerce and government; there appears no prospect of this becoming a problem in the future.

CODE realizes the importance of maintaining up-to-date knowledge of positions taken by the PhD graduates of the Ontario Engineering schools and intends to ensure that such information is updated annually. A copy of a recent survey is included as part of this response. It will be noted from this survey that there has been a shift in the area of employment of engineering PhD's towards industry.

In the light of the consultants' analyses, and of the appended data, there is no need for quotas or ceilings on doctoral students. CODE will continue to report on the number and origins of doctoral students in the various engineering schools, on an annual basis.

Quality Emphasis

(a) Admission

CODE is pleased to note that the consultants have agreed that high admission standards to engineering doctoral programmes generally prevail.

CODE, therefore, supports the contention that existing minimum entrance standards to PhD programmes should be maintained across the Province. CODE believes that a *post facto* analysis of admission practices, widely publicized, will be adequate to ensure this objective.

In application of these standards, it must also be acknowledged that certain defensible exceptions will occur with respect to those with known special abilities or those who have demonstrated superior ability in research, design and innovation in their post-baccalaureate experience.

CODE fully supports the view of the electrical consultants that it is "in Canada's interest, especially in international competition, to have strength in high-technology research and development" and for this to happen there must be an objective of "high standards of excellence with emphasis on quality".

(b) Programmes and Faculty Facilities

CODE recommends that totally independent and representative bodies continue to oversee negotiated development grants and the formation of centres of excellence. These are matters better left outside the jurisdiction of such a body as CODE.

(c) Undergraduate/Graduate Programme Relationship

CODE supports the contention that the continued existence of a live, up-to-date undergraduate programme requires the backing of a good research programme and participation in professional practice by members of the faculty. The research activity, in the prevailing tradition, is most easily met through the provision of Master's and PhD postgraduate programmes.

(d) Quality Indicators

In addition to the observance of university regulations, and the use of high-calibre external examiners, the observed career performance of doctoral graduates can be used as a 'quality indicator'.

Critical Size for Doctoral Programmes

In order to be viable, a PhD programme must provide a sufficient range of interaction for the student. He must be exposed to enough faculty members and enough other students to provide adequate breadth of experience and instruction. The adequacy of this breadth cannot be judged exclusively by the size of the department in which he is registered.

The ACAP assessments, by being completely vertical, miss the rich horizontal components which can and do nourish and sustain viable doctoral programmes in both small and large departments and faculties. Resources from other divisions of the university, other engineering departments, industry and, indeed, other engineering faculties must be considered in any realistic analysis of PhD programme viability.

Size is not a sufficient criterion for judging whether a school can offer a PhD programme; there is no *a priori* reason why a small school cannot provide as satisfactory an environment for the student as can a large school.

Engineering in the Wider Context

CODE would draw attention to the need to view the totality of the PhD programmes in engineering not just in isolation, but also in the context of other related disciplines; e.g., physical, life and social sciences.

To progress technologically in such a way as to improve the quality of life not only in Canada but also in other parts of the world, it is essential that there be work proceeding concurrently in the forefront of various other disciplines which impact on engineering. It is anticipated that increasingly advanced work in various areas will need to proceed in a more integrated fashion and it will be essential to have available high-level manpower in the physical, life and social sciences, economics, and management, for instance, together with similar capabilities in engineering.

Research Emphasis and Relevance

As a result of the ACAP Engineering Assessments, there is now readily available information about research projects underway in all the Ontario

Engineering Schools. The system would have profited more had the consultants commented in detail on this information and offered substantiated specific advice on the topics of emphasis and relevance.

CODE feels that PhD programmes in engineering should be flexible enough to cover a broad range of topics. Research activities could and should range from mission-oriented research of an immediate and perceived social or industrial relevance through to very fundamental or basic research. The overall thrust of PhD research programmes should be towards advancing fundamental engineering knowledge required for the solution of present and future engineering problems.

CODE also feels that a plurality of sources of research support is a relatively effective means of ensuring that a broad spectrum of research activity is undertaken within the engineering schools. The existence of a variety of granting bodies, with a spectrum of interests represented, including a significant academic component, appears to be an effective method of control.

Level of Support for Doctoral Students

CODE strongly supports the contention that levels of support for doctoral students must be increased substantially if more Canadian students are to be attracted to entering doctoral programmes in engineering.

It should be noted that foreign graduate students have been willing to undertake PhD studies at the levels of support available and have subsequently filled positions within Canada. Positions have been available for PhDs these have been filled largely by landed immigrants who have either completed PhD study in Canada or who have come to Canada with a PhD.

The recent increases in both the cost of living and salaries offered by industry to engineering graduates makes it even more urgent that immediate action be taken to increase the support for doctoral students. This is particularly true if post-baccalaureate experience students are to be attracted. Therefore, it is important that more opportunities be available for this particular type of doctoral student in engineering.

Part-Time/Non-Resident Work

CODE would encourage continued experimentation in this regard. It is felt that maintenance of some institutional contact is essential, however. It is felt further that any part-time or non-resident work should normally be by individual arrangement. This would not, of course, preclude special arrangements between a research institution or industry/government laboratories and a particular university or universities.

Inter-University Activities and Facilitating Mechanisms

CODE would support any action designed to increase the effectiveness of the provincial resources in faculties of engineering. The holding of discipline meetings, the sharing of equipment, interchange of credits for graduate courses, collaboration between groups within various institutions and so on are to be encouraged. It is emphasized that cooperation often involves travel and other expenses that are not always readily available in individual schools and that this matter is worthy of further investigation.

It is noted that interuniversity activity is proceeding especially at the 'grass-roots' level and this can be aided and abetted by CODE. It is also noted that various university industrial research institutes and similar agencies have facilitated some interuniversity cooperation largely through use of individual expertise existing at various institutions.

The Role of the PhD in Entrepreneurship

CODE feels that entrepreneurial activity by PhDs is something which cannot be legislated. However, it feels further that the PhD has, by virtue of his total background, significantly greater potential for success in such activity than has the member of the general populace. It suggests that there are two avenues of encouragement which can lead PhDs in greater numbers into entrepreneurship. The first depends on the educational institution itself, which must, by appropriate orientation and emphasis, develop an interest in or leaning towards innovation, independent practice, or entrepreneurship. The second depends on progressive government support programmes of various kinds, directed to reaching a 'climate' competitive with that found in other industrial economies of comparable size.

Cost-Benefit of the ACAP Studies

CODE has noted that no major measures are proposed that would greatly enhance the quality of the PhD effort in Ontario. Indeed, CODE records its pleasure at the broad and independent affirmation of the consultants as to the strengths and qualities which have developed in Ontario PhD programmes.

The full programme of ACAP studies is as yet incomplete. CODE has yet to be convinced that the extensive funds and efforts devoted to the studies would not have been better spent in direct support of existing PhD programmes in engineering.

ANS/dd
December 27, 1973

APPENDIX A

REPORT ON THE CODE ENGINEERING DOCTORATE EMPLOYMENT SITUATION, OCTOBER, 1973

In November, 1973, members of the Committee of Deans of Engineering of the Province of Ontario again supplied data on the status of their engineering PhD graduates during the period November, 1972, until October, 1973. The results are compared in Table 1 with those for 1972.

Again this year, the majority of the graduates were in chemical, civil, electrical and mechanical engineering. The total is up substantially to 177 from 124 in 1972.

Unemployment is up from one in 1972 to three in 1973 (approximately 1.7% of the total).

Approximately 17% have left Canada, which is the same as for previous years and is probably due to the return of foreign students to their home countries.

A notable increase in employment in industry has occurred, up to 33% from 21% in 1972. The number employed in Canadian universities is up to 26% from 21% in 1972. This has been accompanied by a decrease in post-doctoral fellowships from 23% to 11%.

The overall conclusion is that there is still no serious unemployment among recent Ontario PhD graduates in engineering despite predictions to the contrary. In fact, a healthy trend toward their increased utilization in Canadian industry may have been established.

December 13, 1973.

ONTARIO ENGINEERING PhD EMPLOYMENT SURVEY 1973

The employment status of one hundred and ninety-two graduates with PhDs in engineering from Ontario universities during the period November, 72, to October, 73, was determined in November, 1973.

ENGINEERING DEPARTMENT OR DISCIPLINE	Unemployed 1972	Unemployed 1973	No professional Employment 72	No professional Employment 73	Employed in Industry 72	Employed in Industry 73	Employed in Government 72	Employed in Government 73	Employed in Universities 72	Employed in Universities 73	Postdoctoral Fellowships 72	Postdoctoral Fellowships 73	Have left Canada 72	Have left Canada 73	Unknown 72	Unknown 73	TOTALS 72	TOTALS 73
Aero/Space	-	-	-	-	1	3	-	-	1	3	4	1	-	-	-	-	6	7
Bio-Medical	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0
Chemical	-	1	-	-	4	13	1	3	7	5	7	5	3	2	4	2	26	31
Civil	-	1	-	-	5	7	2	5	3	14	6	5	9	7	5	-	30	39
Electrical	-	-	2	-	9	20	3	2	5	11	7	5	4	9	1	-	31	47
Industrial	-	-	-	-	2	-	1	-	2	-	-	-	-	-	-	-	5	0
Materials/Metals	-	1	-	-	1	6	1	-	1	3	2	2	-	3	-	-	5	15
Management	-	-	-	1	-	-	-	-	1	1	-	-	-	1	-	-	1	3
Mechanical	1	-	-	-	4	9	2	5	6	8	1	1	2	7	2	1	18	31
Mining	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0
Physics/Science	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	2	0
Systems Design	-	-	-	-	-	-	-	1	-	1	-	-	-	2	-	1	0	4
TOTALS	1	3	2	1	26	58	10	16	26	46	28	19	19	31	12	4	124	177

APPENDIX B

Comments on CEMC Report

"Supply and Demand for Engineering Doctorates in Canada" (July, 1973)

Submitted by the Committee of Ontario Deans of Engineering

Commendation of this report can be made in a general sense on two main scores. Firstly, the consultants have, on assignment, tackled in a straightforward manner, what is generally acknowledged to be a most difficult task indeed; where qualitatively it is not possible to assert all possible parameters, and quantitatively, it is not possible to obtain reliable data on all accepted parameters.

Secondly, the consultants have in their report introduced with some care statements relating to the qualifications and limitations of the many elements entering into their predictions, and have emphasized that this is only a beginning - ergo, a very preliminary report.

Within this general context, however, there are a number of criticisms to be advanced.

1. Supply

The methodology has been clearly enunciated, and the assumptions stated. Nonetheless, projections have been made on a three-level approach (high, medium and low), establishing bounds which may well be broken as and when certain assumptions become less or more operative. Some indicators are already present as to the dangers of some of the assumptions.

1.1 Admission requirements are not static, and are increasingly adaptable to the changes in the high school. Three other important aspects must be added. There is, firstly, foundation for expecting a major growth in the number of women entering engineering. Secondly, the "market-place" reaction with a rapid response in the first year enrolment to a proclaimed shortage in engineers will continue to be operative. Thirdly, there is further indication that advanced admissions (through the stop-outs returning, through technology graduates admissions, etc.) are increasingly important in enrolment projections. None of these has been clearly taken into account in this report. A further aspect could well be added, which is also ignored in the report, but is less easy to define though it will contribute to the instability in prediction of first year enrolment. This relates to measuring the full impact of major educational changes on the Canadian scene. The effect of the CEGEP's in Quebec in particular, as well as of the CAAT's in Ontario, is yet to be clearly perceived, let alone settled into a measurable or stable influence.

1.2 The two data bases selected for examination were the number of master's degrees and the number of baccalaureates. The discarding of the master's degrees/doctorate degrees ratio as credible seems to ignore the very recent development of many doctorate programmes as contributing to a rapid change in this ratio. The total post-graduate effort in engineering in Canada is of such an emerging character that rates of change must be evaluated much more carefully. This is equally true for the baccalaureate/doctoral ratio selected as a data base. The evidence for stabilization in this is slight, and even the selection of three ratio levels is likely subject to major error through neglect of variable factors in an easily perturbed system. The changing pattern in the number of Canadian baccalaureates who earn doctorates outside the country is one further feature of a system which as yet has little maturity or stability in it. This aspect of immigration was noted in the report as one for which no data was available - which ignores one fullydocumented part of the system, the Athlone Fellows.

1.3 The utilization of the baccalaureate/doctoral ratio as a data base for predicting future supply has another feature which is inadequately considered and analysed. This relates to the forces which are operative on graduates of Canadian engineering schools vis-a-vis their proceeding to doctoral work. Graduates of the engineering schools of Canadian universities have never come forward in substantial numbers to undertake advanced study and research. The tradition of such a choice, and indeed the number of opportunities for such advanced work, are relatively new on the Canadian scene. The expansion of the graduate schools over the past decade has been effected therefore by the attracting of students with overseas degrees, particularly from Asia. Many of these students from overseas have been or have become landed immigrants, have stayed in Canada and have taken jobs as PhDs. These jobs have been available, they have not been taken up by Canadians who seem to have preferred to enter the work-force earlier, immediately after obtaining the bachelor degree. There are probably many factors which have conditioned the particular choices of Canadian engineering graduates at the bachelor level, but primarily it is probably a combination of (a) the fact that they have been so readily absorbed into the economy at that level, and (b) the fact that the level of financial support available for graduate study has been too low to make them feel that the sacrifice is worth it. For the near future, unless the proportion of Canadian bachelor degree graduates choosing to undertake PhD studies changes drastically, the numbers of qualified applicants coming forward will certainly decline. At the same time as the graduate schools in engineering become increasingly well established and recognized, and as high-technology factors including its encouragement through government policies increasingly become operative, the opposite effect could well occur. The imprecision therefore in assuming a stabilized bachelor/doctoral ratio is greater than assumed in the CEMC study.

1.4 In the consideration of the report, moreover, one should not perhaps overlook the possible impact of events occurring in other jurisdictions. The report suggests that the annual number of bachelor degree graduates will fall from about 4,500 to 3,000 over the next three years, with most of this decrease due to a falling-off in freshmen enrolments in provinces other than Ontario. This could suggest in itself a likelihood of fewer qualified Canadian graduates available for PhD studies at our universities. This must be viewed in conjunction with the situation in the U.S. where undergraduate enrolments in engineering have fallen very sharply over the last few years and this will lead to a very substantial decrease in the number of bachelor engineering degree graduates over the next few years. The combined Canada/U.S. graduating class was about 47,000 in 1971. It will be only about 35,000 in 1975. One might wonder whether, because of excellent opportunities at the bachelor level, a smaller proportion might proceed to PhD work or conversely whether the lack of anxiety about employment prospects at the bachelor level will give more students the confidence to continue with their studies.

1.5 A further major criticism of this part of the report rests not on the methodology, elements of which have been discussed above, but on the basic data used in the calculation steps. Without examination of each and every set of data used, it can nonetheless be indicated that the rather complex combinations of undergraduate enrolment and graduation data from Statistics Canada, from EIC enumerations, from the "Ring of Iron" for Ontario leave some inconsistencies. The number of bachelor's graduations and of doctorates were obtained only to 1970-71, while the number of master's degrees were recorded for 1971-72. In view of the rapid build-up in Canada of doctorate degrees (from 78 in 1965-66 to 216 in 1970-71) it would have seemed to be quite important to establish the 1971-72 figures before final projections were carried out. In view of the prominent place taken by the Ontario system contribution it is indeed surprising that more current data at hand in COU (ACAP) was not utilized. Nonetheless, it is fair to point out that the actual doctorates in Ontario for 1972 and 1973 respectively were 124 and 177, and that the former figure compares to the low level projection for 1971-72 of 126, and the latter to the high level projection of 172 for 1972-73. At least the projection band width used just encompasses the first stages of comparative actual data.

2. Demand

The report includes a comprehensive survey of manpower demand methods, and a careful statement of the method followed for each of the sectors explored, as well as its limitations. This demand aspect of the report is the one which has received the most criticism from the ACAP consultants in the five engineering fields assessed. Our criticisms encompass the major elements of those comments in summary form as well as those voiced by the engineering schools in Ontario.

2.1 Educational Sector

The consultants' use of a model for the estimation of future demand in the educational sector is deceptively attractive. Essentially, their model was based on a staff/student ratio as a base, adjusted for retirement, mortality and migration. They concluded that to 1977-78 (at least) the demand for engineering doctorates would be essentially zero, and then admitted "this will not prove to be an accurate scenario". They then rest their case that in both universities and other educational institutions, the demand will be "minimal". In the dictionary sense of the least attainable or extremely minute in size, it is difficult to read into this other than essentially no demand. Even though rather elegantly derived, we find it hard to accept such a conclusion, particularly when the Ontario system itself projects now a demand for about 20 for 1974. Some of the parameters which would be omitted by the model used include increased demand through major block research grants, through mission-oriented research, and through the development of new programmes and areas. The report does deal at length with the question of "substitutability between inputs", but does not weigh it to the level where it would not be balanced by other factors. This question of substitution will also be referred to below in considering the total demand-supply picture.

2.2 Government and Industry Sectors

In these sectors the consultants chose to establish stock data and forecast demand for 1974, 1975 and 1978 by direct survey. From the many criticisms and indeed specific refutations that can be made, it is clear that this survey has been far too narrowly cast. In the government area this is certainly true regarding the narrowness of definition used. In the industry area it includes not only that limiting factor, but became subject to both incomplete data through using wrong sources, and through important omissions. To some degree the consultants were well aware of these deficiencies, but were obviously more conscious of them for the forecast demand data than for the stock data - where equally gross errors and omissions seem to have occurred. One example of such an error is in the stock of 52 in 1973 attributed to AECL, compared to the 90 actual in 1973 as provided by the Metallurgical engineering consultants in their report to ACAP. Other reports to ACAP specify other examples.

It is hard to escape the conclusion that the inadequacies of the demand survey are far greater than the consultants envisioned, and their errors of omission are much greater than they estimated.

3. General

3.1 Educational Planning and Manpower

What appears to be a basic premise of the report as contained in paragraph 1 on page (1) deserves comment, viz.,

> "Now, a generally accepted view is that the expected labour market for graduates of a particular speciality should influence policy and planning in post-secondary education in that area."

This view may not be as generally accepted as one might be led to believe. The particular philosophy outlined can, taken to extremes, result in a shortsighted and constrained view of a university. It could well be argued that too marked a distinction has been drawn between what is educational and what is vocational. Recently this has been convincingly stated to be one of the major misconceptions in higher education planning*. The danger in assuming that all but preparation of people for specific jobs is wrong or wasteful is not just in the short-sighted effort to establish a one-to-one relationship between education and jobs. Rather it omits the important fact that vocationally oriented education is not wasted if it is not used in the specific vocation toward which it was directed. As Bowen* states, "It is no mark of failure, rather a mark of success, that education - even strictly vocational education - has wide applicability and produces flexible and versatile people". The PhD graduate even if he takes a vocational route initially may well very soon find himself in positions where his PhD can be regarded only as part of his general education or as a contributing factor to his intellectual development or problem-solving ability. It is not difficult to give examples of this "diffusion" of PhD's through a "vocational" period to positions of quite different responsibilities in industry, governments and the universities. The consultants gave careful attention at one stage in their report to this "diffusion" or dispersion, referring properly to the recent University of Toronto study. However, they did not then "factor" it in to either their supply or their demand projections. In our view, significant allowance should be made for it. On the supply side, both into the baccalaureate stream as well as into the doctoral stream in engineering the vocational/educational issue is not clear-cut nor should it be. On the demand side, there must be allowance made both for the substitutability through flexibility even at initial employment levels, and for increasing mobility and transfer into wider areas such as management as experience accrues. The difficulty of quantifying this is well appreciated. The need for including it in some definitive way demands equal appreciation.

3.2 The Supply and Demand Balance

The report in it's final results and conclusions comes down strongly on the prediction of an oversupply of engineering PhDs in the decade ahead. They acknowledge a range of factors which will influence both their supply band projection and their demand band projection, including the possible effect of their own report. We acknowledge this danger and can only hope that it can be minimized by vigorous emphasis both on the limitations of the report's projections but also on the countering evidence as it accumulates. We have indicated some of the aspects of both the supply and the demand projections which can invalidate the narrowness of the band widths selected. Perhaps more importantly in the long run is the real failure of any demand projection to be able to take into account any but the very short-term skill requirements of the economy. The evidence is quite clear that our society has an enormous amount of work to be done with a lack of sufficient skilled manpower to do it. We would claim that the adaptability of doctoral graduates in general combined with the adaptability of our economy results in a surprisingly good balance. The Ontario experience, well documented now for four years, indicates essentially no unemployment of engineering doctorates, no unusual hold-up or storage in a post-doctoral form, and changing flows into government and industry as demand from the universities slacken. The acceptance of a current balance, which does exist (with some evidence indeed of unfilled needs in some areas), could well be the starting point for the report's projections. The graphical summary given on page 18 would then present an entirely different picture.

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* H. R. Bowen, "The manpower vs. the free-choice principle", University Affairs, Jan. 1974.

We should rise above our national tendency to be cautious and pessimistic, recognize that even a PhD may be viewed as vocational or educational (hopefully both) according to the graduates perception of the market-place, alternative opportunities, his own desires and so on, and not deliberately cut back on PhD enrolments in engineering, especially on demand data of such doubtful validity as that contained in the CEMC preliminary report. We have so little to gain and so much to lose by taking such an approach. We need to display more optimism and confidence in ourselves and in the ability of highly educated manpower to seek out and create opportunities and to raise the level of some existing positions both in government and industry. It is to be hoped that our students also will display such optimism and take a broader view of the value of their education, and that this view is shared by our federal and provincial governments. We will need this spirit if we are to move into an era in Canadian industry where increasing sophistication and high technology become more and more necessary.

NOTES

Re: 1.1

Entrance to engineering was assumed constant on a demographic base, i.e. 0.5% of male population age 15 to 19; and assumed unchanged entrance requirements.

Re: 1.2 and 1.3

The greatest danger in assuming the validity of a stable B/D ratio for projection purposes resides in the fact that the doctorate figure for the last decade includes a very large but unknown number who did not come through the Canadian baccalaureate stream. The size of that group of doctorates was related largely to immigration policies (now changed and changing), to research grants policies (which have also changed), and possibly to more selective admission policies. Perhaps a meaningful B/D ratio could usefully be established when the D number arises almost entirely from the B stream. Such data have not been collected.